
AUTOMATION OF CALCULATION OF THE STRENGTH AND FAILURE OF STRUCTURES MADE OF COMPOSITE MATERIALS

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Automated systems of calculating the strength of structures are used on an increasing scale throughout the world. Various universal and specialized program packages of the methods finite and boundary elements are proposed [1]. In most cases, these programs are designed for analysis of different structures made of conventional materials. The possibilities of calculating structures made of composite materials by means of the proposed program packages are highly limited because the typical special features of deformation of the composite materials are not sufficiently reflected in the catalogues of finite elements.

1. STRUCTURE OF PROGRAM PACKAGES

Program packages for calculating the strength of structures of composite materials should contain several additional modules in contrast to structures made of conventional materials (Fig. 1). The package programs for analysis of structures of conventional materials contain the modules 2, 3, 6, and also data banks for the properties of structural materials. The catalogs of the finite elements in the module 2 contain conventional finite elements of bars, beams, plates, shells, flat, axisymmetric, and three-dimensional solids. The module 3 contains the conventional theories of the strength and fracture mechanics used for conventional structural materials. The module 6 includes programs for searching optimum solutions which are similar and can be used for optimizing structures made of both conventional and composite materials.

In the program packages for calculating structures of composite materials it is necessary to change greatly the modules 2 and 3. In the catalogs of finite elements, the module 2 should contain finite elements reflected in the special features of deformation of the structure made of composite materials. The remaining programs for analysis of the statics, dynamics, and stability of structures are the same as for analysis of the structures made of conventional materials.

The situation in the case of the module 3 is more complicated. If for structures made of conventional materials, the theory of strength and fracture mechanics has been sufficiently developed, at present there are no completely reliable theories of strength and fracture mechanics of structures of composite materials. It is therefore not possible to conclude that the analysis of the strength and fracture of structures of composite materials can be completely automated.

A program package for the method of finite elements and the method of boundary elements for calculating structures of composite materials

Determination of effective stiffness

Data banks on the properties of components

Analysis of the response of a structure to external effects

Data banks for reinforcement structures and technologies

Analysis of the strength and failure of structures

Search for optimum structure

Fig. 1. Diagram indicating the solution of problems of deformation of structures of composite materials using universal program packages.

Fig. 2. A cylindrical panel of carbon plastic in pulsed loading.

The module 1 is completely new. In this module, the effective thermophysical mechanical characteristics of a composite material are determined on the basis of the properties of the components and for the known reinforcement structure. The methods of finite and boundary elements are efficient methods of solving this problem. A solution is obtained using the main programs of the module 2 which are utilized to determine the stress-strain state in the composite components. The module 1 contains only the programs for the appropriate averaging method.

The module 4 contains data on the mechanical and thermophysical properties of the composite components, i.e., the matrix, fibers, and fillers; the module 5 contains information on the reinforcement structures which can be used in practice. For example, winding technologies used for continuous fibers include conditions for continuity of winding, whereas for shells there are conditions of winding along the lines close to geodesic.

Thus, the program packages for calculating the strength of structures of composite materials are constructed on the basis of the conventional program packages of the methods of finite and boundary elements by widening a catalogue of finite elements and packages and adding new modules. At present, special attention should be given to developing the module 3, i.e., analysis of the strength and failure of structures of composite materials.