DETERMINIG THE STABILITY OF THE LAMINATED COMPOSITE PLATES

Syed Azmath, P.BHARGAV, HANUMANDLU
3.V.SARITHA, 5.Dr.K.SAMMAIAH
Assistant Professor, Department of Mechanical Engineering,, Ellenki college of Engineering and Technonlogy, patelguda (vi)ʾ near BHEL ameenpur (m), Sangareddy Dist. Telangana 502319.

Abstract

The article shows the results of experimental studies of stability, supercritical behaviour and fracture of plates of a layered composite material. Composite plates are made of fiberglass layers glued with epoxy resin. To reliably assess the bearing capacity of laminated plates, numerical and experimental methods are used. A methodology for experimental research of the deformation and strength properties of composite materials using testing equipment has been developed. The difference between the critical strength values of three-layer samples and the critical strength of four-layer samples was determined to be 2-3%. Thus, products from composite materials (unmanned aerial vehicles) can be made from three-layer plates to reduce their weight. Models of two-layer, three-layer, and four-layer plates were performed with the ANSYS program. The obtained experimental results were compared with numerical values. The possibility of using experimental data of the mechanical behaviour of layered composite materials in the design and calculation of unmanned aerial vehicles was estimated.

1. Introduction

One of the main tasks facing designers to create unmanned aerial vehicles is to increase the reliability of the structure [1-2] due to the stability of strength characteristics and the accuracy of aerodynamic contours with a simultaneous increase in manufacturability, as well as creating a structure with a more accurate profile from composite materials [3-4]. Preliminary calculations, experimentally confirmed simulation, introduction of nanomodifications of composite materials allow us to develop a new approach to extending the life cycle of elements and assemblies, increasing the specific strength, rigidity and stability of the structure when working under complex loading (including dynamic) [5], and above all, these lead to a decrease in the mass of structures with an increase in their bearing capacity. Calculations of the stress-strain state of structural elements and the optimal choice of the layering structure of composite materials ensure the strength of the product depending on the perception of external loads. In selecting rational structural and technological solutions for the products, modeling the stress-strain state, optimization and experimental characterization of layered composite materials are of great importance [6]. Layered composite materials have a wide range and a unique combination of properties such as high strength, corrosion resistance, wear resistance [7-8]. A significant role in the process of creating new materials is played by an experimental study on the strength and stability of samples [9].

2. Experimental work

This article presents the results of experimental studies of the stability and fracture of laminated plates made of composite material with a different number of layers. Two series of samples were made, one from fiberglass and the other with the inclusion of foam between the

layers of fiberglass. Samples of the first series of fiberglass are:

• 10 samples of four layers;

• 10 samples of three layers;

• 10 samples of two layers.

Samples were made in the research and production laboratory "Reliability, strength of products and structures" of the East Siberia State University of Technology and Management. The manufacturing of samples involved contact molding by layering in a mold, lubricated with a release coating of reinforcing material (T-10 fiberglass) with simultaneous impregnation of each layer with a binder (epoxy resin with hardener). After impregnation additional rolling was carried out to eliminate air bubbles and ensure the uniform distribution of the resin. At this point a thorough air removal is necessary to avoid interlayer defects that otherwise may occur. Batches of samples consisting of two, three and four layers were made. After forming they were dried and subjected to mechanical processing. Then all the samples were numbered and measured at the cross section of their working part. Using, The width and thickness in different sections of the sample were measured by a micrometer and an electronic caliper. Deviations both in width and thickness were ±0.1 mm.

Samples for the experimental determination of the mechanical characteristics of composite materials satisfy the following requirements [9]:

• the ability to implement simple standard loading schemes;

• simplicity and low cost of the device for testing;

• ease of installation in the testing machine and testing;• insensitivity to the method of attachment;
• reproducibility of experimental estimates of the studied characteristics. Figure 1 shows the manufacture and preparation of samples for testing.

Figure 1.Production and preparation of samples for experiments.

Accurate determination of the mechanical characteristics of composite materials is possible using modern equipment with high accuracy of recording loads and movements. The experimental work was carried out on the universal Instron 3367 machine. During compression tests, the test specimen is installed in the grips between the movable and fixed traverses. The loading of the sample is carried out by moving the active capture in a given mode. During the test it is possible to implement loading modes of the sample with a constant rate of change in stress, force, movement of the active capture or deformation. The measured parameters (forces and displacement) are converted by the sensors and the control unit of the machine into electrical signals, which are displayed on the monitor screen of the control computer in the corresponding tension or compression diagrams. Figure 2 shows photographs of test equipment for compressing plates.

Figure 2. Test machine Instron 3367.

3.   The results of experimental work

The first batch of samples consisted of ten four-layer plates of the following sizes: t = 2 mm, h = 19.6 mm, l = 170 mm. The plate was installed in the clamps and the load was set at the speed

of v = 50 mm min-1. When the critical force was reached (figure 3), the plate lost stability but continued to take the load until it collapsed. The critical load, the load during the destruction of the sample was determined. The results of four-layer samples are presented in figure 4.
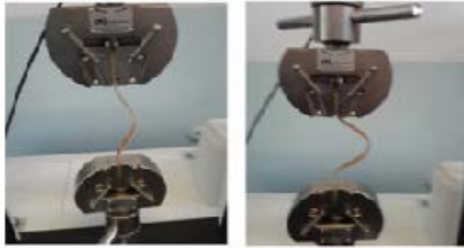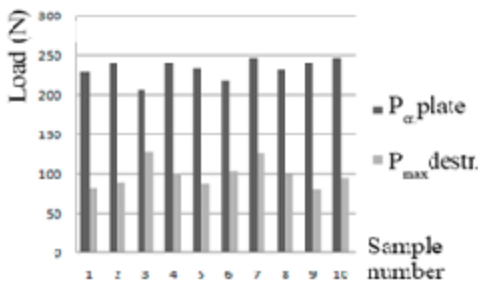

Figure 3.Compression test of two-layer plates.

Figure 4. Compression of four-layer

samples numbered 1 to 10.

The second batch consisted of ten three-layer plates (samples No. 11 to 20) of the following sizes:

t = 2.5 mm, h = 20 mm, l = 170 mm. The results are presented in figures 5, 6.

Figure 5. Compression of three-layer samples numbered 11 to 15.
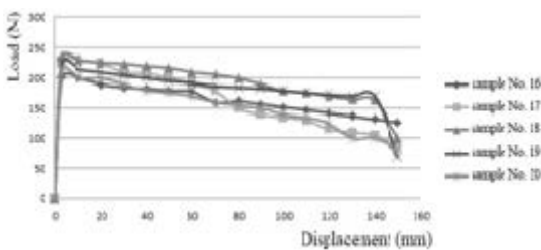

Figure 6. Compression of three-layer samples numbered 16 to 20.

4.   Computer simulation of layered composite plates Two-layer, three-layer and four-layer plates ere simulated by ANSYS. The

results of numerical calculation by the finite element method are presented in figures 9 and 10 for the deformed state and stress state of a three-layer plate, respectively.
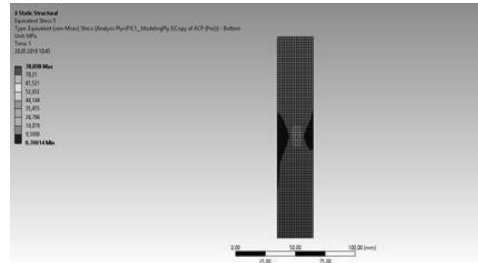

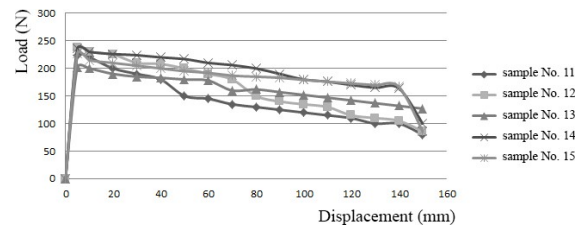**Figure9.**Deformedstateofathree-layerplateintheANSYSsystem(mm).

Figure 10. The stress state of a three-layer

5.   Findings

A set of experiments was performed with samples from multilayer composite materials and the following results were obtained:

•   Four-, three- and two - layer samples from composite materials were tested. The values of the critical load and that of the load at failure were obtained.

•   A manufacturing procedure of samples was developed. It was found that the discrepancy between the critical load of four-layer samples and that of three-layer samples was 2–3%. Therefore, three-layer plates can be used to reduce the weight of the products made from composite materials. The discrepancy between the critical load of three-layer samples and the critical load of two-layer samples was 19–21%. The discrepancy between the experimental and numerical values was 7–8%.

References

[1]   Andreev Yu V et al. 2015 Problems of standardization of the strength of UAV

structures Proc. of Scientific and Technical Conf. "Strength of Aircraft Structures" (Proc. of TsAGI) (Zhukovsky:

Central Aerohydrodynamic Institute Press) pp 69–78

[2]   Bolsunovsky A L, Buzover N P, Kazhan V G, Kazhan A V and Fomin V M 2005 Calculated and experimental studies of the aerodynamic characteristics of the thematic UAV model Materials of the XVI School-seminar "Aerodynamics of Aircraft" (Zhukovsky: Central Aerohydrodynamic Institute Press) p 24

[3]   Villasenor J 2014 "Drones" and the future of domestic aviation Proceedings of the IEEE 102(3)

235–8

[4]   Gupta L, Jain R and Vaszkun G 2016 Survey of important issues in UAV communication networks IEEE Communications Surveys & Tutorials 18(2) 1123–52

[5]   Bokhoeva L A, Bochektueva E B, Zaitsev V A, Perevalov A V and Chermoshentseva A S 2012 Dynamic testing of aircraft products Materials of the V Int. Conf. "Issues in Modern Machines Mechanics" vol 2 (Ulan-Ude: East Siberia State University of Technology and Management Press) pp 65–9

[6]   Bokhoeva L A and Bochektueva E B 2018 Development of a multi-channel measuring system for experimental research of aeronautical products Materials of the VII Int. Conf. "Issues in Modern Machines Mechanics" vol 1 (Ulan-Ude: East Siberia State University of Technology and Management Press) pp 151–5 additives on the properties of composite materials with interlayer defects Aerospace MAI Journal 24(3) 212–21

[7]   Bokhoeva L A and Damdinov T A 2006 Determination of critical loads by energy method with shear deformations Vestnik KGTU im. A.N. Tupoleva 1 3–7