DESIGN OF AIR WINGS WITH TRANSVERSE SHEAR FEASIBILITY AND INVESTIGATION OF DYNAMIC AND STATIC CHARACTERISTIC

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Abstract

The objective of the work is to determine dynamic loading of air wings using Fem with axial compressive characteristic under strength and bucking constraints deploying the air wing design. The composite plate responses are sensitive to transverses shear deformation effects, and hence an accurate formulation has been employed for composite plates which includes the transverse shear deformation effects. Towards this, a plate formulation has been used which calculates the buckling load including the effects of transverse shear flexibility. The formulation first address the buckling problem of uni – axially and bi – axially loaded composite plates under simply supported boundary conditions and to study effect of angle of twist on natural frequencies of different plate and also considering the different Ply orientation.

I. INTRODUCTION

An introduction of new technology follows the development and use of modern materials. Today, composite materials are the subject of an intensive development and use. These materials have significantly better mechanical and other characteristics than their constituent elements.

Properties of composite materials that make them more specific than other materials are: large strength, high stiffness, small density and mass, resistance to corrosion and high temperatures, the ability to create complex shapes. Most of composites are created in order to improve the combination of mechanical characteristics of materials, such as stiffness, toughness and strength in conditions of environment influences, or at higher temperatures. These materials also have a considerable potential for absorbing kinetic energy during crash [1]. The ability of these materials to meet the specific needs for different structures makes them highly desirable. Improvement in design, materials and manufacturing technology enhance the application of composite structures.

Because of their extraordinary mechanical properties composite materials have an important application in aircraft constructions. The technology has been explored extensively for aerospace applications, which require high strength and stiffness to weight ratio [2]. Carbon/Epoxy composites are the most used composite materials in primary structures of the aircraft. They are usually used in a form of multilayer composites (laminates). For the implementation of composite materials in aviation, the most important feature is their behaviour on the dynamic loads and resistance to fatigue [3]. Nowadays the amount of composite materials in modern aircraft constructions is increasing.

Quantity and degree of damages created in aircraft structures may be different. Such damage may have little influence, but may be critical for the construction integrity and service life. For that reason, it is essential to determine the actual construction state because of damages.

Preventing failure of composite material systems has been an important issue in engineering design. The two types of physical failures that occur in laminated composite structures and interact in complex manner are intralaminar and interlaminar failures. Intralaminar failure is manifested in micro-mechanical components of the lamina, as fiber breakage, matrix cracking, and separating of the fiber-matrix interface. Generally, structures made from fiber reinforced composite materials are designed that the fibers carry the bulk of the applied load. Interlaminar failure, such as delamination, refers to separating of adjacent lamina. The possibility that intralaminar and interlaminar failures occur in structural components is considered a design limit, and establishes restrictions on the usage of full potential of composites. Due to the lack of through-the-thickness reinforcement, structures made from laminated.

Ials and adhesively bonded joints are highly susceptible to failure caused by interfacial crack initiation and growth. The delamination phenomenon in a laminated composite structure may reduce the structural stiffness and strength, red.

istribute the load in a way that the structural failure is delayed, or may lead to structural collapse. Therefore, delamination is not necessarily the ultimate structural failure, but rather it is the part of the failure process which may ultimately lead to loss of a structural integrity [2].

The basic design characteristics of modern aircraft are the use of complex software packages, in both design and service. Most of these softwares are based on the Finite Element Method (FEM). With the help of these programs, it is possible to determine the accurate number of measurable places on the structure, with increasing.

Stress values. This enables optimization of necessary measure equipment, which is integrated on aircraft and directly contributes to shorten the time of testing and project price reduction. The same kind of procedure provides an opportunity for tracking defects in structures during their service life within maintenance procedures.

II. FINITE ELEMENT METHOD (FEM)

Finite Element Method (FEM) is a numerical method of structural analysis [6]. The basic idea of this method is a physical discretization of a continuum. This implies a dividing accounted domain (some structures) on the finite number of small dimensions and simple shapes, which represent the basis for all considerations. This makes a mesh of so-called "'finite elements"'. Over discretization of a continuum, one type of finite elements or combination of several types may be used. The finite elements are connected by common nodes, so that they make the original structure. Mesh generation is the division of a certain area on nodes and finite elements. Commercial software packages have a built-automatic division of the areas for the purpose of obtaining one faster as well as qualitative solutions. This is of big importance in large or very complex engineering tasks [8].

Theoretically viewed, the discussed domain has infinite degrees of freedom. With this method, such a real system is replaced by the model, which has a finite number of degrees of freedom. With a mathematical perspective, instead of differential equation system, which defines equilibrium state of the entire model, the FEM use provides a common system of algebraic equations. Move from a mathematical to physical domain, the entire process comes down to complicated (but solved) system equations. At certain conditions the loads act only in certain points of finite element, which are called nodes. On the basis of well-known displacements in nodes, determination of stresses in nodes can be done, as well as in other points of final elements, which enabled stress-strain analysis of structures. The basic task is to choose the model which best approximates the appropriate boundary conditions. In case of lack of exact criterion, which was largely a matter of engineering and intuitions, quality knowledge of the nature of discussed problems, the theory of finite element allows to get response to this very important question [7].

The FEM is used to find out: stresses and deformations in the complex and unusually shaped components; conditions of fluid flow around buildings; heat transfer through gases and in other applications. A complete model takes into account geometry components, used materials, load conditions, boundary conditions and other significant factors. Appropriate use of FEM permits that component is tested before it is made. Consecutive iterations of that part would be modified, in order to attain the minimum weight with supply of an adequate strength. To view the basic equations in the FEM, various methods are used [7].

The main advantage in structure projects by computer use is the possibility of simulations. In that way, the behaviour of structures in real working conditions is examined. The investigated model replaces the real construction with a certain accuracy [9]. Sometimes it was necessary to create a physical model to examine its properties. Today, most of the work on the design is done in virtual environment [6].

The finite element method is the dominant discretization technique in structural mechanics. It was originally an extension of matrix structural analysis, developed by structural engineers. The FEM has been used in every field, where differential equations define the problem [8]. The process implementation of the FEM, based on solving differential equations, is leading.

To the residue method (Galerkin method) or to the variation methods (principle of virtual work, the principle of minimum potential energy). In a deformable bodies mechanics various methods are usually used, since their use is relatively simple.

It can be said that the FEM solution process consists of the following steps:

- Divide structure into piece elements with nodes (discretization/meshing);
- Connect (assemble) the elements at the nodes to form an approximate system of equations for the whole structure (forming element matrices);
- Solve the system of equations involving unknown quantities at the nodes;
- Calculate desired quantities (e.g., strains and stresses) at selected elements.

The FEM is used in deformable bodies mechanics to solve various static and dynamic problems. There are linear and nonlinear FEM analyses. Linear FEM analysis is based on a few basic assumptions: theory of small deformation, material is linear elastic. Nonlinear MKE analysis takes into account the material nonlinearity and geometrical nonlinearity (large deformations) of a considered system.

A Problem Sketch

- The basic configuration of the twisted composite curved panel of length '*a*' breath '*b*' and height *h*, twisted through an angle Φ, as shown in below figure.

Stable – in which case displacements increase in a controlled fashion as loads are increased

Unstable – in which case deformation increase instantaneously, and the structure collapses catastrophically, and referred to as snap – through buckling. The structure may have post – buckling strength in new equilibrium position.

B. Scope of Study

The convergence studies of dynamic characteristics are made for

- Orthotropic plate - square plate ($a/b = 1$; $b/h = 20,100$) considering twist (Φ) having the ply orientation (θ) of:
- 0°/ – 0°/ 0° 60°/ – 60°/60°
- 15°/ – 15°/15° 75°/ – 75°/75°
- 30°/ – 30°/30° 90°/ – 90°/90°
- 45°/ – 45°/45°
- Angle of twist (Φ) – (0°, 15°, 30°, 45°)
- Material used – E-glass epoxy, Graphite epoxy,

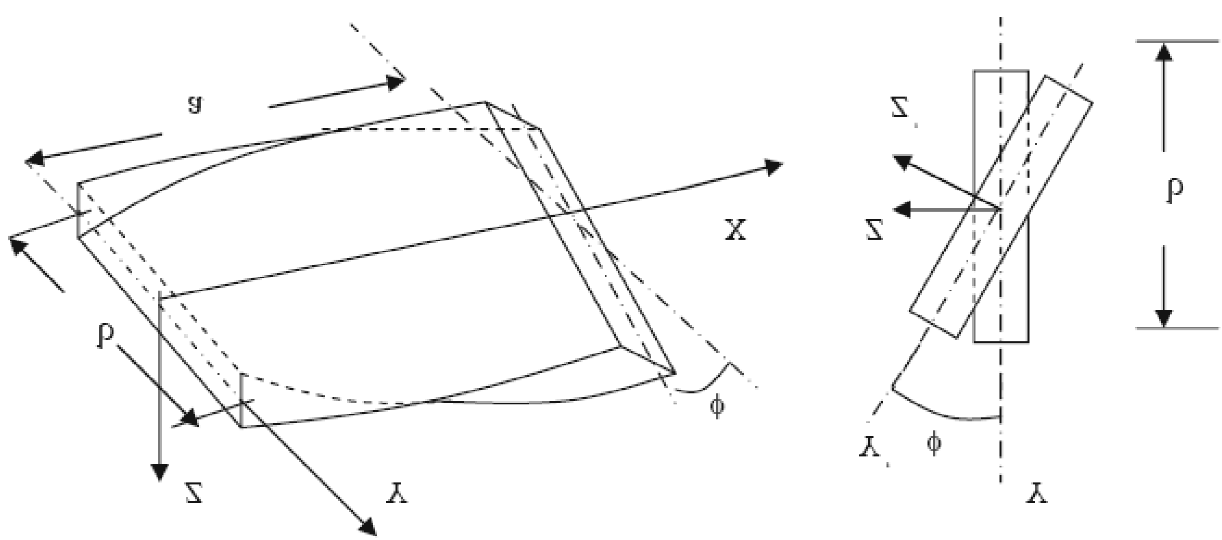

Fig. 1. Configration of twisted composite curved panel

III. RESULTS ND DISCUSSIONS

Eglass-epoxy

Table 1. Material Properties of Eglass-epoxy

Material property	Value
Modulus of Elasticity	
E_{YY}	$60 \times 10^9 Kg/m^3$
E_{YY}	$24.8 \times 10^9 Kg/m^3$
E_{ZZ}	$24.8 \times 10^9 Kg/m^3$
Modulus of Rigidity	$12 \times 10^9 Kg/m^3$
G_{XY}	
G_{YZ}	$12 \times 10^9 Kg/m^3$
G_{XZ}	$12 \times 10^9 Kg/m^3$
Poisson ratio μ	0.3
Density ρ	2324.76 Kg–mass/m^3
Volume fraction	83.26%
Eglass	
Epoxy	16.73%

Graphite-epoxy

Table 2. Material Properties of Graphite

Material property	Value
Modulus of Elasticity	$138 \times 10^9 Kg/m^3$
E_{XX}	
E_{YY}	$8.96 \times 10^9 Kg/m^3$
E_{ZZ}	$8.96 \times 10^9 Kg/m^3$
Modulus of Rigidity	$7.1 \times 10^9 Kg/m^3$
G_{XY}	
G_{YZ}	$7.1 \times 10^9 Kg/m^3$
G_{XZ}	$7.1 \times 10^9 Kg/m^3$
Poisson ratio μ	0.3
Density ρ	1316 Kg–mass/msup[3
Volume fraction	55.60%
Eglass	
Epoxy	44.40%

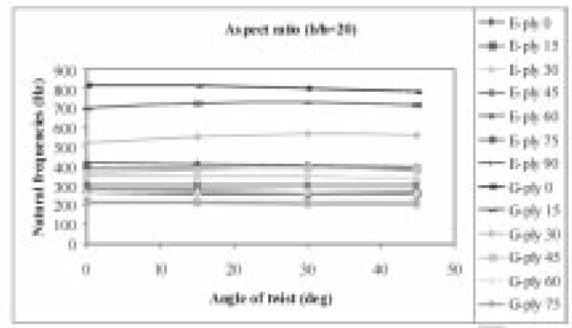

Fig.2 Eglass-epoxy and Graphite-epoxy

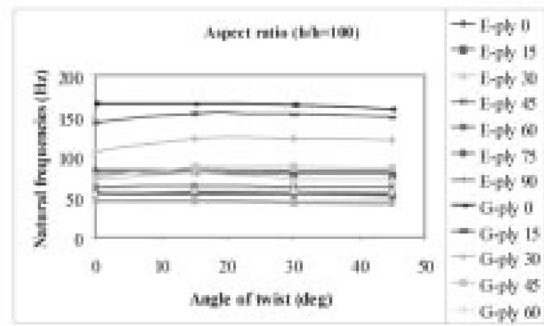

Fig.3 Eglass-epoxy and Graphite-epoxy

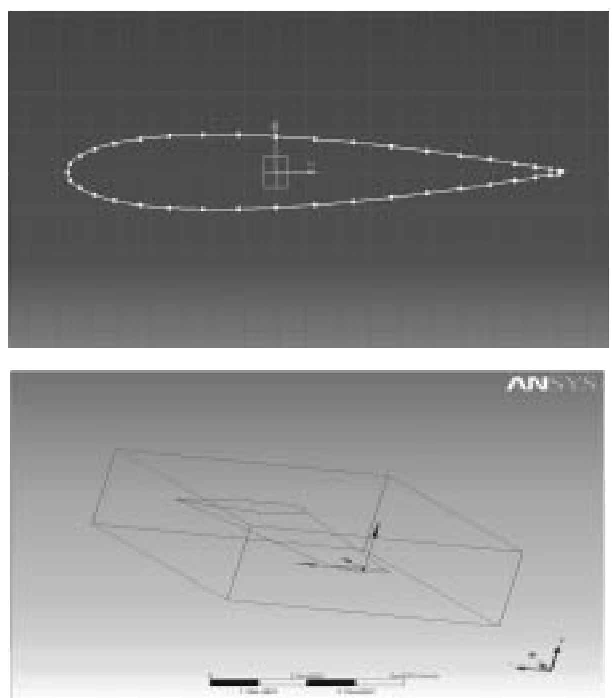

Fig 4. Cross section view of airwings

IV. CONCLUSION

The objective of the present project work is to use a variable formulation for buckling analysis of air wings. With this objective, a mathematical formulation is employed which predicts the buckling load including the effects of the shear deformation. The formulation employed can deal with plates with simply supported edge conditions. The loading conditions considered are uniaxial and biaxial compression loads. The buckling loads obtained from this formulation are compared with results of other formulation. The effect of material properties, mesh size and results from various plate theories are discussed.

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