ANNALS OF THE ORADEA UNIVERSITY
Fascicle of Management and Technological Engineering
ISSUE #1, MAY 2013, http://www.imtuoradea.ro/auo.fmte/

ON THE NUMERICAL ANALYSIS OF LAMINATE COMPOSITE

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Abstract—In this paper we analyze laminate composite materials by numerical methods. Stiffness and strength is the basic concept for underlying the mechanics of fiber-reinforced advanced composite materials. We write a Matlab program that assists the user to find out the stiffness matrix of a laminate composite. The main objective of the paper is to show the advantages and ease use of Matlab software in composite materials analysis. To demonstrate the capability of the program an numerical example was presented.

***Keywords*—**composite laminate, stiffness matrix, constitutive equations, MATLAB

I. INTRODUCTION

NUMEROUS papers have been published on the analysis and design composite material. Because composite materials are produced in many combinations and forms the designer engineer must consider many design cases.

In study of structural response composite material is often analyzed by analytical methods and by numerical methods [2], [3], [8], [9]. This requires a large amount of calculations that depend on many parameters. Calculations of macro-mechanical proprieties and calculations of the constitutive equations involve many matrix manipulations. The manual calculations would take long time. Solutions was to write computers programs.

Numerical computing package MATLAB was used as a basis for the programs because the facilities offered in matrix computations [1], [4], [6], and [7]. The main objective of this paper is to show the advantages of using MATLAB to analysis of composite material.

We illustrate these features by analyzing orthotropic laminate composite material. Fiber-reinforced composites are analyzed by two-dimensional theories. The Kirchoff – Love hypothesis is used. The objective is to write a program to determine the laminate constitutive equations for multi-layered composites. This approach follows the conventional methods for designing composite structures. When an orthotropic materials is in a plane stress state the relationship between the stresses and strain involve the four elastic constants E_1, E_2, ν_{12},and G_{12}. In section II we present the characteristics of unidirectional composite material as functions of the characteristic of the fibres and the matrix. In section III we will review basis assumptions for study the constitutive relations for fiber-reinforced composite and calculate stiffness matrices for laminate, ABBD matrix. In sections IV details for computational approach have been outlined. How to coding in MATLAB software has been outlined step-by-step procedure. A numerical application is presented in section V. In section VI we present the conclusions.

II. EVALUATION OF ELASTIC CONSTANTS

Stiffness and strength is the basic concept for underlying the mechanics of fiber-reinforced advanced composite materials. This aspect of composite materials technology is sometimes terms micromechanics, because it deals with the relations between macroscopic engineering properties and the microscopic distribution of the material's constituents, namely the volume fraction of fiber. The purpose of this section is to predict the material constants (also called elastic constants) of a composite material by studying the micromechanics of the problem, i.e. by studying how the matrix and fibers interact.

There are three different approaches that are used to determine the elastic constants for the composite material based on micromechanics. These three approaches are [2], [3]:

1. Using numerical models such as the finite element method.
2. Using models based on the theory of elasticity.
3. Using rule-of-mixtures models based on a strength-of-materials approach.

Terminology used in micromechanics:

- E_v , E_m -Young's modulus of fiber and matrix
- G_f , G_m -Shear modulus of fiber and matrix
- ν_f , ν_m -Young's modulus of fiber and matrix
- V_f , V_m -Volum fraction of fiber and matrix;

There are four elastic constant of a unidirectional lamina:

- Longitudinal Young’s modulus: E_1