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Influence of the individual layers of laminate on the final static response

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Abstract

The thesis based on a model example, describes in details the formulation of composite materials in simulation software. Furthermore, it points out the influence of the material properties orientation in composite materials by means of a comparison between two geometrically identical models with different material properties orientations. Changes in stress of layers were achieved through changes in orientation. The results of the achieved maximum stress levels are systematically processed in the table, in which the influence of orientation across the individual layers may be clearly observed.

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1. Introduction

Composites are modern but not universal materials. A composite material is a material made two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. They are always designed for a specific use with the aim of their maximum matter usage. Composites are considered to be versatile primarily thanks to their high measurable solidity and firmness, favorable fatigue limit and the fact that they are rather frost-proof. Composites represent a qualitative change in solving the contradictory issues between required characteristics and capabilities of homogenous materials. It is often needed to take into account requirements which are truly contradictory and non-achievable by the properties of one homogenous material. The choice of possible combination of the materials is, therefore, a compromise which arises from fulfilling the primary requirement on the final properties of components. Composites are direction-oriented materials, what mean that the material properties orientation shall influence them. [2,3,4,6]

Nomenclature

$^{\circ}$	Degree of angle
E_1, E_2, E_3	Young Module
FEM	Finite element method
F_1, F_2	Force
G_{12}, G_{13}, G_{23}	Shear module
mm	Millimeter
MPa	Mega pascal
ν_{12}	Poisson number
N	Newton

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2. Simulation of fiber composite materials

A computer simulation using FEM is not a simple procedure at homogenous materials, at composites the calculations are even more demanding. The formulation and evaluation of a composite material model from final elements at the same geometry is more time-consuming than of a model of isotropic material. When using orthotropic material, it is needed to define the material orientation. Layered elements, shell elements and the number of integration points at the thickness of the shell, they all result in a greater amount of data in comparison with a non – layered material. This fact is associated with a more demanding results evaluation. There are several types of software that are successful in solving these issues; one of them is Abaqus/CAE, which we used. Abaqus/CAE offers two types of shells for modeling the composites:

- Conventional shell – a geometry modeled on reference area, which does not have to be identical with the centring area of the shell. This one offers the option of specification for the lower, middle and upper surface.
- Continuum shell – this one can work with continuum geometry, where the thickness will be determined by the geometry. When defining the composition of the laminate only relative thickness of laminas are entered to the total thickness. [1,10,11,]

3. Computing model formulation protocol

When evaluating the influence of single layers of laminate on the final properties of a composite material the calculations were done for a simple-shaped model. The exact procedure of the computing model formulation can be found in the following:

- The model geometry designing – geometry that might be more specifically defined as 3D, compliant and shell body was formed in the module Part. The parameters of the used model may be seen in Fig. 1, the protrusion of the shown design being 40 mm.

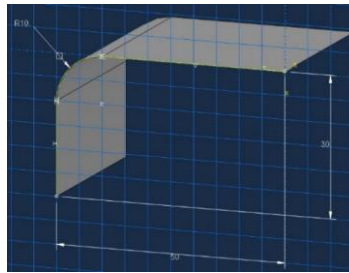


Fig. 1 Geometry of numerical model

- Coordinates system definition – as the materials are direction-oriented, it was needed to define the coordinates system. As the coordinates system according to which the fibers were supposed to get oriented is identical to the global coordinates system, it was not necessary to create a new one. The software managed to get the material properties oriented correctly thanks to assigning the coordinates system orientation to the model. The long-fibered composites, which show orthotropic properties, have three mutually perpendicular plains of the material properties symmetry. The plains are determined by pairs of orthogonal axes labeled as 1, 2, and 3, so called material axes. The axis 1 – alongside the fibers, the axes 2, 3 – perpendicular to the fibers. The highest solidity may be, therefore, seen in the direction of the axis 1.

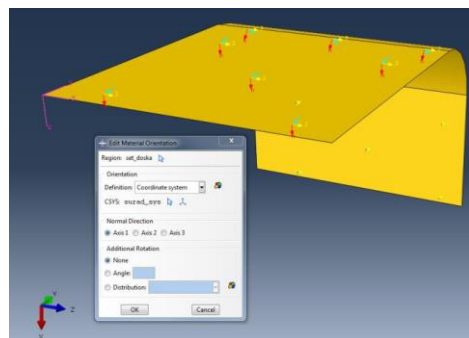


Fig. 2 Definition of coordinate system

Coordinates system shown in Fig. 2, on the basis of which the individual layers are oriented in dependence on the angles set in the Fig. 3 and Table 1.

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