Buckling Load of an Elastic Composite 3D Column

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This paper presents a novel exact solution for the buckling load of 3D columns consisting of two rigidly connected materials. We build on the seminal work of Simo [1] and use a 3D beam model to derive a set of equations that form the basis for our exact solution. The paper is divided into three sections. In the first section, we introduce the axioms and basic equations of the beam model, which are linearized around the primary equilibrium configuration. In the second section we explain the solution procedure and in the third section we present an illustrative example. In the illustrative example, we focus on a straight column with a constant cross-sectional area consisting of two different materials. We show how different boundary conditions and their spatial orientation with respect to the cross-sectional plane influence the buckling load of such a column. The presented solution is useful when we want to evaluate the bearing capacity of a column that be cannot designed based on the minimum buckling load due to technical, spatial or other constraints.

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Formation of Glutinous Biocomposites Based on Secondary Raw Materials of Biocomposite Products

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Accumulation of plastic and synthetic materials in landfills poses a significant threat to the environment [1]. There is a problem of disposal of plastic products. Solving this problem requires a comprehensive approach in the development of the technological process of manufacturing and processing materials, taking into account economic, ecological and social factors. Modern technology development is aimed at implementing a cyclical system of production and consumption, which provides for the maximum use of resources with minimal impact on the environment [2, 3].
The development and use of biocomposite materials is an important component of the process of sustainable development, as such products are manufactured using renewable raw materials. The mechanical properties of fiber-reinforced biocomposites depend on the content and type of fibers,

their orientation and dispersion, as well as the adhesion between the fibers and the polymer matrix. It is advisable to use wheat gluten, polylactic acid (PLA) [1, 4] and soy resins [5] as a biopolymer matrix. Plant fibers are often used as fillers for biocomposites, in particular lignocellulosic [4], sisal [6], ramie, flax, cotton, hemp, abaca, bamboo, etc. Of particular interest are biocomposites filled with food and agricultural waste.

Biocomposite materials are biodegradable, which ensures the process of disposal of products in the natural environment without the release of harmful substances. However, the economic efficiency increases in the case of the use of secondary raw materials, which are obtained as a result of the processing of biocomposite materials. The study of the mechanical properties of biocomposites, which include the raw materials of recycled biocomposite products, is of scientific and practical interest.

The technological process of obtaining secondary raw materials for glutinous biocomposite products includes the stage of diffusion saturation of the components with water, followed by mechanical grinding and drying of the raw materials. Glutin macromolecules remain on the surface of organic filler particles. They determine the strength of the new product. In the case of using a concentration of 30% glutin solution during heat treatment, cavities are formed due to insufficient content of biopolymer binder. The compressive strength of these biocomposite samples is low (8.6 MPa), which is due to insufficient wetting of the filler binder during heat treatment. The highest compressive strength values of the biocomposite samples (25.7 MPa) were obtained in the case of a 40% glutin solution concentration, which is due to the optimal content of glutin molecules in the aqueous solution. The compressive strength of the biocomposite material with a concentration of 50% glutin solution decreases to 9.2 MPa. In this case, the matrix has a higher viscosity, so the wetting of the surface of the filler particles with the binder is worse.

Heat treatment is an important component of the technological process of forming biocomposite materials. Heat treatment increases the fluidity of the glutinous binder and improves wetting of the surface of the filler. Water turns into a gaseous state during heat treatment at a temperature of 140°C, which leads to the formation of structural defects in the biocomposite due to the intensive removal of steam from the material. Therefore, it is necessary to reduce the moisture content in the composition, which is a mixture of components of recycled biocomposite products. The compressive strength of biocomposites increases to 9.2 MPa with increasing the loss of moisture in the composition up to 16% due to the formation of a dense structure with a high number of physical and chemical bonds between the components of the biocomposite material.

The optimal content of gluten in the solution (40%) and moisture in the composition (16%) is an important technological factor that determines the strength of a new biocomposite material based on secondary raw material. It was experimentally established that the plasticity of the biopolymer matrix increases with a low content of glutin in the solution. The rigid structure of the biopolymer matrix is formed with a high glutin content. The low moisture content in the composition reduces wetting of the surface of the filler particles. A high moisture content in the composition causes the formation of a defective structure due to intensive removal of water molecules.

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Improving Energy Absorption in Flexibile Auxetic Structures through Optimization Analysis

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In the search for innovative possibilities for lightweight materials with exceptional energy absorption capabilities, the focus of this investigation is on exploring the properties of flexible auxetic structures. Auxetic structures are characterised by a negative Poisson's ratio and offer the unique advantage of providing high energy absorption with minimal weight, making them ideal for various lightweight applications, including in the aerospace industry.
A comprehensive methodology combining experimental and numerical analyses is used to improve energy absorption in flexible structures. The first phase involves an optimisation analysis in which the geometric parameters are systematically investigated to determine the optimum energy absorption. In the experimental stage, a digital image correlation system (DIC) is used in quasi-static tensile tests to enable precise measurement of strains and their derivatives in flexible, planar structures. Particular attention is paid to the load-dependent Poisson's ratio during the test sequence. The numerical part uses a finite element simulation with the hyperelastic Mooney-Rivlin material model to characterise these structures macroscopically. Based on the results of the simulation, an analysis is carried out in which the simulated strains are compared with the corresponding experimental results in order to validate the model. In addition, the stresses and absorbed energy are calculated.
Based on this, the 3D structures are analysed in detail. In a subsequent investigation, samples with thin-walled Auxetic shells are simulated under pressure. The results show an influence of the auxetic structures on energy absorption, especially under dynamic loads. This work aims to establish a relationship between the Poisson's ratio and the energy absorption associated with 3D structures and thus expand the understanding of their mechanical behaviour.

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