Objective / Research Hypothesis

The objective of this research project is twofold: to examine the stability and post-critical states of compressed thin-walled composite structures with complex cross-sections, made of fibrous composites in **asymmetrical layouts of composite layers, and to investigate the effect of mechanical couplings in the critical, post-critical states and in the phase of failure.**

The research will be carried out with the use of interdisciplinary research methods, combining experimental tests on real composite structures, numerical calculations by the finite element method, as well as the methods of analysis of the structure and properties of materials - including the NDT methods. In addition, mechanical and limit properties of the manufactured composite material will be determined in compliance with relevant standards. The research will investigate the behaviour of thin-walled composite structures under axial compression over the full range of loading, including their behaviour. Verification of the developed analytical-numerical and numerical FE models will be carried out through experimental research. The results of the study will contribute to the development and improvement of methods for analysis and design of thin-walled composite structures with asymmetrical layouts of composite layers.

The research hypothesis is that the stability and post-buckling behaviour of thin-walled composite structures depend on appearing in them mechanical couplings. The selection of appropriate mechanical couplings has a significant impact on the critical load value, the post-critical equilibrium path and on the load-bearing capacity.

Research Methodology

The research will involve making a series of short thin-walled composite profiles with complex cross-sections with different laminate layouts using mechanical couplings. The elaborated physical models will be subjected to homogeneous compression, which will perform on structures simply supported between the upper and the lower clamping head of a testing machine and at the same time, they will be aligned using specially prepared centring elements. During the study, the sample's parameters will be measured by the electrical strain gage technique (deflection), laser sensor deflection measurement (deflection), acoustic emission technique (emission acoustic signal), Aramis system (deformation) and high-speed camera and digital microscope (damage phenomenon). The research will investigate the stability, post-buckling behaviour and load-carrying capacity of compressed composite structures depending on the applied asymmetrical laminate stacking sequence with specific mechanical couplings. Parallel to the experimental tests, numerical calculations will be carried out by FEM in a way reflecting the experimental conditions. To determine the load-bearing capacity of the composite structure the stress failure criteria available in the FEA software will be used. The experimental results conducted on real structures will validate the developed models.

Impact of the expected results on the development of science, civilization and society

The project is multidisciplinary, covering the problems of composite structure mechanics and stability, as well as the mechanics of failure and materials science. The influence of the mechanical couplings for the selected asymmetrical composite layout on the stability, post-critical characteristics and carrying capacity of the composite profiles will be investigated, thus adding to the state of the art in this field with respect to composite thin-walled structures. The innovative character of the research primarily lies in producing composite samples with different shape of cross sections (design and development of both autoclave production technique for samples and necessary equipment) and experimental testing of manufactured samples with respect to their non-linear stability and load-carrying capacity (using numerical simulations to evaluate failure phenomenon), considering the effect of mechanical couplings on the stability and limit states of structures under axial compression. The results will provide information about the development of mechanical properties of laminate structures, as well as they will help optimize the structure of the laminate such to obtain the desired characteristics.
This research will also help to enhance the skills the project's principal investigator and contractors, in particular the employed young researchers, in the field of experimental research and numerical simulation. This help as well as to increase in scientific research results through publications in both domestic and international scientific journals.