The aim of the research project is the analysis of stability, as well as post-critical and limit states of the compressed thin-walled composite profiles with complex cross-sections and a general ply layup. Because of their specifics, thin-walled structures exhibit sensitivity to many factors, which can essentially influence their behavior in working conditions, both in critical states and post-critical or limit states. These factors can be of geometrical, material or mechanical nature. All of them can contribute to premature failure of the structure, still working under allowable loads. A lack of the load axiality leads to essential change in stress and strain distribution in comparison to a structure subjected to perfectly axial load or simple bending. The novelty of the project compared to the results given in the open literature is an attempt to assess both qualitatively and quantitatively the influence of the load eccentricity, as well as initial geometrical imperfections on the behavior of the compressed thin-walled composite profiles within their full load range.

The research will be of hybrid nature, connecting the experimental tests with analytical-numerical solutions and the FEM numerical outcomes. The main problem will be the solution of nonlinear stability and load-bearing capacity of thin-walled composite structures. The considerations will address the behavior of composite structures subjected to an eccentric compressive load, leading to complex stress and strain states in the construction. The analyses will be carried out within the full load range taking into account the failure phase. The results of numerical simulations and analytical-numerical results will be compared with experimental research which will enable the introduction of possible improvements in the numerical models. To determine the load-bearing capacity of the structure, stress composite failure criteria available in the FEM software will be used, such as, among others, the maximum stress criterion, the Tsai-Hill's criterion, the criterion of Azzi-Tsai-Hill, as well as the tensor Tsai-Wu’s criterion.

It is hypothesized that thin-walled composite structures are sensitive to the eccentricity of the compressive load application, which has a significant impact on the stability, the post-critical behavior and the load-bearing capacity of the structures. Moreover, the important factors are the composite ply layup, as well as the structure’s geometry, including its initial deflection, which can prevent the premature loss of stability and capacity of the structure.

The planned research will have an important cognitive value, with respect to the problems of modern design and optimization of thin-walled composite structures, which are increasingly used in many modern applications (eg. aircraft structures, automotive parts, wind turbines, etc.). The use of the thin-walled composite components in load-bearing structures, which includes open- and closed-section profiles, allows to reduce the mass of the structure and to obtain a wide margin of the structural load-bearing capacity, i.e. the ability to work after stability loss, sometimes reaching 2-3 times the critical load . Such properties of fiber-reinforced composites definitely place these materials above metallic structural parts, achieving permanent deformation of approx. 150% of the critical load. The problems of analysis and design of thin-walled composite structures are areas not yet fully known, in particular in relation to the load-bearing capacity and failure mechanisms for composite materials. Thus, the analysis of the influence of the load misalignment, the composite layup and the geometric imperfections on stability, post-critical states and the load-bearing capacity of thin-walled composite profiles are still current issues in the area of mechanics of failure of composites and thin-walled structures.