The aim of the project is to analyze the behavior of compressed elastic plate elements with cut-outs with variable geometry and to examine influence of these parameters on the formation of post-critical equilibrium paths of such structures.

In this study, thin plate elements made of fibrous composites will be analyzed. The study will involve analysis of the stability and load capacity of composite elastic elements with cut-outs in order to determine the effect of the cut-out size and shape as well as of the laminate layout on the post-critical characteristics the elastic element and the value of failure load. Thin-walled structural components are load carrying structures which can work after the loss of stability, provided that they are in the elastic state. This is a significant limitation regarding components made of conventional structural materials such as metals, as their work in the post-critical range is determined by the yield strength of material. Permanent deformation of a structural element results in a significant reduction in the mechanical properties of the structure in the post-critical state. The group of materials which maintain their elastic characteristics in the post-critical range, practically until failure, are composite materials, particularly glass fiber reinforced plastic (GFRP) and carbon fiber reinforced plastic (CFRP). Given their favorable strength properties in relation to density, these materials are now widely used in modern thin-walled structures.

The application of thin-walled components in load-carrying structures allows to ensure the minimum mass of a structure due to optimization of geometrical and material properties. Another advantage of composite materials is the fact that the mechanical properties of a thin-walled load-carrying part can be shaped by selecting a laminate layout depending on the type of the carried load. This allows to shape the constructional properties of load carrying structures, while maintaining the same geometric and material parameters. These factors account for the increasing use of composite materials in modern aircraft or automotive structures, and the problems of mechanics and failure of composites are among the main issues of basic research, requiring the application of interdisciplinary research methods.

The research hypothesis is that plate elements with central cut-outs made of fibrous composites can have static elastic characteristics in the post-critical state, wherein a significant impact on the formation of the plates' elastic properties is exerted by the geometrical parameters of the cut-out and the sequence of composite layers.

The project is multidisciplinary, covering the problems of composite structure mechanics and stability, as well as the mechanics of failure. 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 nonlinear and elastic characteristics. The fundamental objectives of the project will be conducted using FEM numerical simulations and experimental tests, which will enable verification of the proposed methods of modeling and analysis of the nonlinear stability and failure of composite plates. Load capacity of composite structures will be determined by a composite stress failure criterion, i.e. Tsai-Wu tensor criterion. The results of numerical simulations will enable examination of work of thin-walled elastic elements, leading to determination of the effect of the composite lay-out on the post-critical characteristics and load capacity of such structures. The experiments conducted on physical models of the plates with a central cut-out will enable validation of the developed numerical models, thereby describing the state of strain and stress of the structure in the post-critical range and during failure. The accuracy of the numerical results obtained with the Tsai-Wu criterion regarding the load capacity of the tested plate structures will also be verified. Knowledge in the area of basic research in the mechanics of composite materials and the mechanics of failure will therefore be extended with both qualitative and quantitative description of mechanical phenomena causing the loss of stability and the failure of the composite structure. The results of numerical calculations will provide important information with respect to rational design of composite structures, leading to obtaining the required characteristics of the plate in the post-critical range. Given the insufficient knowledge about the mechanisms of failure in composite structures, it is necessary to get more insight into this problem, particularly in light of the increased use of these structures as responsible elements in modern thin-walled load-carrying structures.