DESCRIPTION FOR THE GENERAL PUBLIC

The beams are the main elements of the structure carrying the load mainly by bending. The possibility of carrying relatively large loads with thin-walled beams is limited in most cases not by their strength, but mainly by their stability. In the vast majority of bars they are made of steel. Nowadays more and more structures made of composite (laminates) begin to be designed and used by engineers. In the classical theory of composites, in case of different orientation of main axes of orthotropy at each layer the additional coupling between longitudinal, flexural and torsional stiffness could appear. This distinguishes the design of composite structures from isotropic (steel) and forced to pay special attention to the new phenomena of thin-walled design of multilayer structures.

Thin-walled composite elements (beams, bars, girders, etc.) are currently used in many responsible structures. The usage of the thin-walled elements in supporting structures allows to ensure a minimum weight design by optimizing the geometrical parameters and material, because they are characterized by high strength properties in relation to their specific mass. Mentioned properties determine the ever-growing use of these materials in modern designs.

The project will deal with a nonlinear instabilities of thin-walled composite beams with open cross-sections (channel, top-hat or lipped cross-section) subjected to bending in the plane of the web. There are not possible to describe all buckling modes applying the classical designs on beams with compact cross sections, or in the framework of classical theory of thin plates. Since the late 80s of twenty century the following new theories to analyse stability have been developed: Generalized Beam Theory (GBT), FSM (Finite Strip Method), DSM (Direct Strength Method), constrained Finite Strip Method (cFSM). The authors of the proposed project have developed an original analytical-numerical method (ANM). It allows a complete analysis of the nonlinear instabilities taking into consideration all forms of buckling shapes, from local to global buckling modes through their interactive forms.

In the latest world literature the attention to the significant impact of the global complex form (known as distortional) on the lateral-torsional buckling mode of long steel beams subjected to bending have been drew. In the literature there are no papers dealing with an analysis of nonlinear interactive instabilities of short and medium-length beams. The submitted project is proposed to fill this gap with particular emphasis on composite structures. During the preliminary experimental tests and numerical calculations conducted by the authors of the project the phenomenon of a complex interaction of different buckling modes have been observed.

In this project is planned to carry out a number of experimental tests on channel sections composite beams of short and medium-length and subjected to bending. The results of performed tests will allow to describe all the phenomena occurring in the process of buckling in the whole range of load, up to failure. The study will use a digital image correlation system (Aramis) for track the deflection of tested beams, and 3D laser scanner for mapping the initial geometry of tested samples.

In numerical (FEM – finite element method) calculations the commercial package ANSYS will be employed. The calculations will be carried out until failure of the structure using the available in FEM package failure criteria (e.g. Tsai-Wu) and by adding its own procedures to enable the application of other failure criteria like for example Puck, Hashin, or Hoffman criterion. The developed analytical-numerical method (ANM) will also be employed. This method allows to analyse the impact of various forms of buckling to work of analysed structures. Understanding the observed phenomena of interactive instabilities of short and medium-length beams and describing it allows for a more complete assessment of their impact on work of short, mid-length and long beams. FEM as a very general method, allows for comprehensive analysis of a variety of phenomena, however, the separation of individual phenomena is difficult or even impossible in contrary to the ANM.

The observed phenomenon and the measured quantities will allow for validation of FE models. Developed refined numerical models will allow precisely analyse the phenomenon of interactive instabilities occurring in the bending of short and medium-length composite structures.

Solution to problem posed may allow for the implementation of research results into practical applications. It also improves the modelling approach the desired mechanical properties of composite materials. The results will be published in several scientific articles and papers at international and national conferences.