Popular science abstract of the project

The current design trends and requirements imposed on modern structures motivate engineers to optimize and design them more effectively. This refers mainly to the usage of material. Therefore, structures need to be designed in such a way that the least amount of material is used to carry the design loads. This results in the smaller weight of structures and lower the consumption of raw materials that increases the competitiveness and reduces the environmental impact. Efficiency can also mean multi-functionality. In the case of structural members, it is combined high strength and stiffness, safety and better performance. These features have thin-walled, cold-formed beams and columns. They are used in different industries, e.g. civil engineering (warehouses, storage racks), mechanical engineering, automotive industry (car and bus frames, trailers), aviation, agricultural machinery. The subject of research are beams and columns with non-standard cross-sections subjected to four-point bending and axial compression. They are made of cold-rolled steel sheets using manual and CNC bending machines. Experimental investigations are based on optical measuring techniques and systems OptoCAD, Aramis and Atos. They are used for non-contact measurements of 2d and 3d strains and processing of scan results. This approach provides a deep insight into the buckling and collapse of beams and columns. Optical measuring techniques overcome drawbacks of strain gauge measurements. They can be used to verify and improve numerical and theoretical models of beams. The considered structural members with non-standard cross-sections are subject to four-point bending and axial compression. The investigated beams and columns have channel cross-sections. They are chosen, because they are prone to point loads. The main goal of researches is to analyse the influence of imperfections on the stability and strength of beams and columns. The secondary goal is to evaluate the usefulness of optical measuring techniques in experimental investigations of thin-walled cold-formed beams and their comparison with other methods. At the beginning, actual beams are 3d scanned in order to determine their actual imperfections that are unavoidable when making them using bending machines, even CNC ones. The scanned models will be compared with their theoretical (ideal) counterparts. In the next stage, the actual beams are tested on universal test machines. The results of experimental tests will be compared with the results of numerical simulations based of FEM and FSM. The quantitative (stresses, strain, critical and limit loads) and qualitative (overall deformation and buckling modes) data will be compared. Ansys and SolidWorks Simulation will be used for numerical simulations that refer to the scanned and theoretical (ideal) beams. These numerical investigations make it possible to directly compare and measure the influence of actual imperfections on the strength and stability of beams and columns. The obtained result will be compared with theoretical solutions that may be found in Eurocode 3. They will be also used to create or improve theoretical models of beams that include imperfections. Optical measuring techniques and the aforementioned advanced software make it possible to process results of measurements during and after tests. This speeds up the entire research process. This is a big improvement as compared to strain gauge measurements, because the obtained data show strains / stresses not only in a few points, but at the entire surfaces like in FEA. This raises the question if such an approach better explains the influence of imperfection on the strength and stability of beams and columns. At this moment in time, there are not many scientific papers presenting the application of optical measuring techniques in such problems. Preliminary results referring to a sample channel beam prove that those techniques make it possible to evaluate the influence of actual geometrical imperfections on the strength and stability of thin-walled cold-formed beams. The differences between critical and limit loads of actual and theoretical beams subjected to four-point bending may be a few or more percent. The obtained knowledge is very useful when designing, manufacturing and assembly of such structural members.