Ph. D. Thesis: ***Optimization of the mechanical behavior of beams with box sections***

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## Abstract

This work was focused on the study of efficient solutions to for the improvement of the mechanical behaviour and movement capability of industrial devices with mobile parts subjected to bending and torsion combined loads. In order to achieve the aim of developing efficient engineering solutions, several stages were followed.

A bibliographic research was performed in order to select the most suitable geometries for the project. The search engine Sciencedirect.com was used for this purpose. After an extensive search, the all-metal sandwich geometries were selected. The selection was motivated by their high efficiency related to the unitary mass. Other geometries were analyzed, such as cellular structures. However, they did not show feasibility for their incorporation in optimization processes, mainly due to the difficulty of defining relevant design variables.

Beams with a new configuration were designed and calculated in the commercial Finite Element software ANSYS MECHANICAL APDL. The feasibility of the novel beams was evaluated numerically by the comparison with conventional hollow-box beams. In bending, displacements in the direction of the load application were studied, while in torsion both, displacements and distortion angle were subjects of considerations. Satisfactory level improvement was obtained for all beams under bending, and also for some of them in torsion.

A sensitivity analysis was done to one of the beams in order to determine the influence of each variable in the mass and in the displacements parameter space. A methodology was developed to determine the best value of the weights to consider for the mass and displacements, to incorporate in the objective function.

The new beams developed were then optimized using custom prepared MATLAB optimization code and a novel objective function. The optimization performed by coupling MATLAB with ANSYS software together with the objective function was defined according to the project goals: to decrease displacements, while keeping the beam mass at a minimum. Several parameters were developed, in order to evaluate the efficiency of the code and of the geometries, both in terms of stiffness and strength.

The last step of the work was the design of a physical prototype using CAD AUTODESK INVENTOR software. The chosen studied beam was manufactured by steel sheet cut, and then TIG welding. A sample of sheet was tested to both rupture and elastic domain only, to determine the main mechanical properties: Young's modulus, yield strength, and Poisson coefficient values. The beam was tested mechanically with unsymmetrical loads, in order to validate the numerical results in loads equivalent to coupled bending and torsion. The main conclusion was – the developed solutions present realistic possibilities of industrial applications, and that the main aims of the work were accomplished.

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