

PRACTICAL OPTIMUM SHAPE DESIGN OF THIN-WALLED OPEN CROSS SECTIONS SUBJECTED TO BI-AXIAL MOMENT AND TORSION USING SOFT COMPUTING TECHNIQUES

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Abstract

A thin-walled section is referred to as a shape in which the thickness of an element is less than one-tenth of the width. The use of thin-walled open cross sections in the design of structural elements in civil, mechanical, marine and aerospace engineering becomes necessity because of the requirement of special shapes that are unavailable in the list of standard hot rolled sections. These sections offer several advantages such as a high strength, material saving and ease of handling and transportation. This is why they are widely used in building and bridge construction, storage racks, transmission towers, automotive, ship and aircraft industry. However, they also have disadvantages. One of the main disadvantages is their weak torsional rigidity which is much less than their closed counterparts. Thin walled open cross-sections are manufactured either made from structural plates that are formed into desired shapes by roll forming or by welding steel plates to each other if the required thickness is thickly. In general the thickness is uniform throughout these section. In either case, the cross-sectional optimization is necessary to be able to achieve efficient use of steel material.

In this study, the optimum shape design algorithm is presented for the shape problem of thin-walled open sections subjected to bi-axial bending and torsion considering the practical design requirements in addition to strength and serviceability limitations. The mathematical model for the shape problem is constructed by treating the nodal coordinates of a thin walled section as design variables. The displacement, normal and shear stress limitations are considered as design constraints while the objective function is the minimum weight. In the computation of the stress values under the external loads the effect of warping is taken into account. This is calculated by using Vlasov's torsion theory. For this purpose a routine is used which calculates the sectional and sectorial properties of the thin-walled-section by utilizing nodal coordinates. The solution of the optimum design problem is determined by using soft computing technique. The enhanced artificial bee colony (eABC) and population based beetle's antenna search (pbBAS)

algorithms are employed for this purpose due to their efficient performance in the previous studies. In the design examples considered it is noticed that the optimum shape of a thin-walled open section is closely related with the upper and lower bounds selected on the nodal coordinate variables. Allowing large freedom on these design variables may end up the optimum shapes that might not be practically usable while controlling the upper and lower bounds yields practically usable shapes.