Analytical Criteria for the Evaluation of the Internal Forces at the Elastic and Plastic Limit States of Lozenge and Triangular Cross-Sections

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ABSTRACT

The elastic-plastic methods for the design of steel structures have been introduced in some national codes, in Europe and America, for almost half a century. This innovation has resulted from the recognition of these design methods for a better estimation of the ultimate resistance of some types of steel structures.

These methods are often based on some hypotheses, such as the formation of plastic hinges in the most stressed cross-sections. The development of these plastic hinges is affected by the interaction between the axial force and the bending moment acting on the cross-section.

The interaction criteria between these internal forces depend on the cross-section shape. Therefore, specific analytical criteria are required for each type of cross-sections, and for each combination of bending moments over the two main axis of inertia of the cross section (in the case of bi-axial bending).

However, these criteria are not usually available in the design codes or text books for most of the cross-section shapes, especially for those that are less common in steel construction. Even in the case of the most usual cross-sections, the analytical criteria are often defined by means of simplified expressions. In the meanwhile, the use of new shapes is becoming more frequent, due to bold innovative structural solutions conceived by modern architects.

This paper presents a set of analytical criteria for the evaluation of the internal forces (axial force and bending moment) in lozenge and triangular steel cross-sections, at their elastic and plastic limit states. They are written in a non-dimensional form, which makes them independent of the cross-sections dimensions and of their width-to-height ratio.

These criteria are based on the hypothesis of a full yielding of the cross-sections at their plastic limit state. The material is supposed to present elastic-plastic behaviour without hardening. The effects of eventual shear or torsion deformations on the cross section are supposed to be negligible.

These analytical criteria put in evidence the different behaviour of symmetrical and non-symmetrical cross-sections, regarding their axis of bending, at their elastic and plastic limit states. They constitute a basis for the elaboration of more complex analytical criteria, for hollow lozenge and triangular cross-sections, or for rectangular full or hollow cross-sections submitted to axial forces and bi-axial bending. A worked example shows an application of these criteria to the evaluation of the elastic and plastic limit states in a square section submitted to an axial force and bi-axial bending. Another worked example presents the expressions for the evaluation of the maximum eccentricities of an axial force in a triangular section, at its elastic and plastic limit states.

References

[1] Ch. Massonnet, M.Save, *Calcul Plastique des Constructions. Vol 1 – Structures dépendant d'un Paramètre*. Ed. B. Nelissen, 3rd Edition, 1976.