SECOND INTERNATIONAL CONFERENCE ON
"COUPLED INSTABILITIES IN METAL STRUCTURES"
LIEGE, BELGIUM, SEPTEMBER 5-7, 1996

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NON LINEAR BUCKLING OF TAPERED COLUMNS

ABSTRACT

The design of tapered compression members, according to the latest version of Eurocode 3, is not covered by specific expressions, allowing the direct calculation of their buckling resistance. These elements must be verified using second-order analysis or simplified methods, based on modifications of the basic procedure for uniform members.

This paper presents a semi-analytical geometric and material nonlinear model for the analysis of bidimensional steel structures including tapered members.

This model allows to take in account the main sources of material nonlinearities, such as hardening, residual stresses and the spreading of plasticity, along the cross sections and length of the structural members.

The second-order effects are taken in account through an updated lagrangian formulation for the structure kinematics. The control variables are the global deformations of the cross section.

The calculation of the section's efforts and stiffness is developed analytically, for all possible combinations of the global deformations evolution. The resulting expressions, written in a non dimensional form, enable a fast computation of these variables, independently of the dimensions of the cross-section.

The geometry of the tapered members is defined by the parameters of previously

chosen functions, which allow the calculation of their cross sections dimensions at any point of their lengths. These dimensions are used as scale factors, for the evaluation of the section's efforts and stiffness in a dimensional form. In this study, it is supposed that the variation of the cross section dimensions along the member's length is linear, which corresponds to the most common cases in practice.

Some examples of the elastic and elastic-plastic buckling resistance computation for tapered members are presented. The values found with these calculations are compared with those obtained by other design methods.

The results of the numerical simulation of experimental studies are also compared with the corresponding test results, published by their authors.

Other studies are carried on in order to calibrate some of the simplified methods commonly used for the analysis of the tapered members behaviour.

In particular, the importance of the type of discretisation, when calculating a tapered element as a series of subelements with constant section, is analyzed. The influence of the definition of the cross section's properties, for each one of these subelements, over the error of the solution is also studied. The conclusions of these studies will provide useful information about the proper choice of these parameters, and will allow the designers to have a notion about the corresponding improvement on the results, when using this simplified method of analysis.

Another application of considerable interest, consists on using this model on parametric studies, in order to develop specific expressions for the design of tapered members, taking in account the main factors affecting their behaviour, such as the second order effects, the spreading of plasticity, the effects of hardening, the influence of residual stresses, etc.

Furthermore, the good performance of this model allows its application on reliability studies, which might help to improve the existing design rules for this type of structural elements.