Stability Design by Geometrical Nonlinear Analysis Using Equivalent Geometric Imperfections

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Abstract : The present article describes the research that deals with the development of equivalent geometric imperfections for the stability design of steel members considering lateral-torsional buckling. The application of these equivalent imperfections takes into account the stiffness-reducing effects due to inelasticity and residual stresses, which lead to a reduction of the load carrying capacity of slender members and structures. This allows the application of a simplified design method, that is performed in three steps. Application of equivalent geometric imperfections, determination of internal forces using geometrical non-linear analysis (GNIA) and verification of the cross-section resistance at the most unfavourable location. All three verification steps are closely related and influence the results. The derivation of the equivalent imperfections was carried out in several steps. First, reference lateral-torsional buckling resistances for various rolled I-sections, slenderness grades, load shapes and steel grades were determined. This was done either with geometric and material non-linear analysis with geometrical imperfections and residual stresses (GMNIA) or for standard cases based on the equivalent member method. With the aim of obtaining identical lateral-torsional buckling resistances as the reference resistances from the application of the design method, the required sizes for equivalent imperfections were derived. For this purpose, a program based on the FEM method has been developed. Based on these results, several proposals for the specification of equivalent geometric imperfections have been developed. These differ in the shape of the applied equivalent geometric imperfection, the model of the cross-sectional resistance and the steel grade. The proposed design methods allow a wide range of applications and a reliable calculation of the lateral-torsional buckling resistances, as comparisons between the calculated resistances and the reference resistances have shown.

Keywords : equivalent geometric imperfections, GMNIA, lateral-torsional buckling, non-linear finite element analysis