A stability analysis of axially loaded thin-walled beams with point-symmetric open section using corotational finite element formulation

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ABSTRACT

The geometrical nonlinear stability analysis of axially loaded thin-walled beams with point-symmetric open section is studied using corotational finite element formulation [1]. The axial load passing through the centroid of beam cross section and the bimoment induced by the axial load are considered in this study.

The shear center and centroid of the point-symmetric cross section are coincident. The beam element proposed in [1] for thin-walled beams with generic open section is adapted and employed here. The element has two nodes with seven degrees of freedom per node. The deformations of the beam element are described in the current element coordinate system constructed at the current configuration of the beam element. The element nodal forces are derived using the virtual work principle. All coupling among bending, twisting, and stretching deformations of the beam element is considered in element nodal forces by consistent second-order linearization of the fully geometrically nonlinear beam theory.

An incremental-iterative method based on the Newton-Raphson method combined with constant arc length of incremental displacement vector is employed for the solution of nonlinear equilibrium equations. The zero value of the tangent stiffness matrix determinant of the structure is used as the criterion of the critical state.

A straight thin-walled Z section beam subjected to a centric compressive force P at both ends studied in [2] is considered. All degrees of freedom excluding warping are restrained at one end and only the axial displacement and warping are permitted at the other end. The bimoments at the beam ends due to axial force P are $P\omega_c$ and $-P\omega_c$, respectively, where ω_c is the value of warping function at the loading point. Numerical results show that the prebuckling twisting angle of the beam is large, and the critical state corresponding to the lowest critical load is flexural buckling. The value of the lowest critical load is much larger than that of corresponding Euler buckling load, and that of the torsional buckling load given in [2], in which the prebuckling deformation is not considered. We may conclude that for axially loaded thin-walled beams with point-symmetric open section, the prebuckling twisting angle of the beam induced by the bimoments has a predominant influence on the lowest critical load and the type of the corresponding critical state.

REFERENCES

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