Distortional solutions for loaded semi-discretized thin-walled beams

For thin-walled beams, the classic theory for flexural and torsional analysis of open and closed cross-sections can be generalized by including distortional displacements. In a companion paper it is shown that using a novel semi-discretization process, it is possible to determine specific distortional displacement fields which decouple the reduced order differential equations. In this process the cross section is discretized into finite cross-section elements, and the natural distortional modes as well as the related axial variations are found as solutions to the established coupled fourth order homogeneous differential equations of GBT. In this paper the non-homogeneous distortional differential equations of GBT are formulated using this novel semi-discretization process. Transforming these non-homogeneous distortional differential equations into the natural eigenmode space by using the distortional modal matrix found for the homogeneous system, we get the uncoupled set of differential equations including the distributed loads. This uncoupling is very important in GBT, since the shear stiffness contribution from St. Venant torsional shear stress as well as "Bredt's shear flow" cannot be neglected nor approximated by the combination of axial stiffness and transverse stiffness, especially for closed cross sections. The full analytical solutions of these linear non-homogeneous differential equations are given, including four illustrative examples, which illustrate the strength of this novel approach to GBT. This new approach is a considerable theoretical achievement, since it without approximation gives the full analytical solution for a given discretization of the cross section including distributed loading. The boundary conditions considered in the examples of this paper are restricted to built in ends, which are needed for future displacement formulation of an exact first-order distortional beam element.

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