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Geometrically Nonlinear Vibration Analysis of Timoshenko Beams Using the Weak Form Quadrature Element Method

***M. Liao[1] and H. Zhong[2]**

[1]College of Civil Engineering, Chongqing University, Chongqing, China
[2]Department of Civil Engineering, Tsinghua University, Beijing, China

*Corresponding author: liaom@cqu.edu.cn

Geometrically nonlinear vibrations of Timoshenko beams are investigated by the recently proposed weak form quadrature element method. The nonlinear effects of axial deformation, bending curvature, and transverse shear strains are considered. The weak form description of the beam is formulated on the basis of variational principles. The integrals involved in the functional are evaluated by an efficient numerical integration scheme and the partial derivatives at the integration points are approximated by differential quadrature analogs. The number and placement of the points are adjustable in accordance with convergence requirements. A system of algebraic equations is eventually derived and the ratios of the nonlinear to the linear frequencies are extracted from solving the equations. Their variations with the slenderness ratio and the ratio of amplitude to radius of gyration under various boundary conditions are examined. Comparisons with available results demonstrate the strength of the proposed method.

Keywords: Timoshenko beam, Nonlinear vibration, Weak form quadrature element, Variational principle