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Static and Dynamic Post-Buckling Analyses of Irregularly Constrained Beams under the Small and Large Deformation Assumptions

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Abstract

Post-buckling phenomenon has been performing advantages in many applications. In particular, buckling snap-through of slender beams under lateral constraints is of great research interest since low-rate and low-frequency excitations can be transformed into high-rate motions. Electrical energy can be generated from ambient energies through the process. Efficient conversion of the energy phases requires sufficient control over post-buckling response. However, inadequate studies have been conducted to investigate the influence of different lateral constraints on buckling mode transitions. This study aims at developing static and dynamic theoretical models to capture buckling snap-though of slender beams subjected to irregularly bilateral constraints. The models are created based on small and large deformations assumptions, respectively. An algorithm is introduced to discretize the irregular constraints into a gap vector. The equilibrium equations in the presented models are solved using an energy method that minimizes the total energy in the gap vector with respect to the weight coefficient (C_m) of different buckling modes. Experiments were carried out to validate the theoretical results. Good agreements were observed. The proposed models are then used to investigate the effects of the linearly and sinusoidally varied constraints on the beams' post-buckling response. It is found that the deformed shapes of the beams meet the patterns of the constraints. Both the static and dynamic large deformation models are able to measure the end-shortenings that result in severe rotation of the beams' neutral axes. Significant shifting is observed between the deflected beam shapes solved by the static and dynamic models. The presented models are effective in understanding and predicting the static and dynamic post-buckling responses of irregularly constrained beams under small and large deformation assumptions.

Keywords: Small and large deformations; Post-buckling response; Static and dynamic models; Irregularly bilateral constraints; Energy method