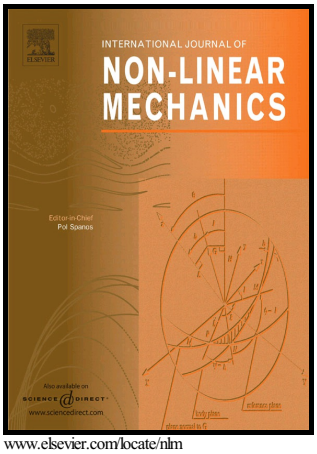

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Linear and geometrically nonlinear analysis of non-uniform shallow arches under a central concentrated force

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Abstract

In this paper an integral equation solution to the linear and geometrically nonlinear analysis of non-uniform in-plane shallow arches under a central concentrated force is presented. Arches exhibit advantageous behavior over straight beams due to their curvature which increases the overall stiffness of the structure. They can span large areas by resolving forces into mainly compressive stresses and, in turn confining tensile stresses to acceptable limits. Most arches are designed to operate linearly under service loads. However, their slenderness nature makes them susceptible to large deformations especially when the external loads increase beyond the service point. Loss of stability may occur, known also as snap-through buckling, with catastrophic consequences for the structure. Linear analysis cannot predict this type of instability and a geometrically nonlinear analysis is needed to describe efficiently the response of the arch. The aim of this work is to cope with the linear and geometrically nonlinear problem of non-uniform shallow arches under a central concentrated force. The governing equations of the problem are comprised of two nonlinear coupled partial differential equations in terms of the axial (tangential) and transverse (normal) displacements. Moreover, as the cross-sectional properties of the arch vary along its axis, the resulting coupled differential equations have variable coefficients and are solved using a robust integral equation numerical method in conjunction with the arc-length method. The latter method allows following the nonlinear equilibrium path and overcoming bifurcation and limit (turning) points, which usually appear in the nonlinear response of curved structures like shallow arches and shells. Several arches are analyzed not only to validate our proposed model, but also to investigate the nonlinear response of in-plane thin shallow arches.

Keywords: Shallow arches, Geometrically Nonlinear Analysis, Snap-through, Non-uniform arches, Analog Equation Method.