

Bifurcation analysis of thin structures using Asymptotic Numerical Method

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Thin shells are widely used in aerospace, automotive, and civil engineering due to their mechanical advantages. However, they are highly sensitive to instabilities such as buckling, which depend on geometry and material properties. Numerical modeling plays a key role in understanding and designing these structures, particularly in achieving all equilibrium configurations.

This paper analyzes the stability of thin shells using the Asymptotic Numerical Method (ANM) combined with Padé approximants. This approach effectively solves nonlinear problems by accurately detecting singular points along solution branches. Three techniques to detect bifurcations are studied: (1) a bifurcation indicator based on a fictitious perturbation force, (2) the analysis of poles in Padé approximants, and (3) the evolution of natural frequencies related to stability.

Traditional methods for solving nonlinear problems, such as Newton-Raphson iterative algorithms, are computationally expensive and require appropriate strategies to track complex response branches. ANM provides an efficient alternative by developing the solution as asymptotic series, reducing the number of matrix decompositions required. The use of Padé approximants improves significantly the validity range of the solutions.

In this study, we present an overview of numerical examples that highlight the advantages of the Asymptotic Numerical Method in solving nonlinear problems and efficiently analyzing bifurcations in strongly nonlinear systems.