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Abstract

The equation of motion of curved beams is derived in polar coordinate system which represents exactly the geometry of the beam. The displacements of the beam in radial and circumferential directions are expressed by assuming Bernoulli-Euler's theory. The nonlinear strain-displacement relations are obtained from the Green-Lagrange strain tensor written in cylindrical coordinate system, but only the components related with radial and circumferential displacements are used. The equation of motion is derived by the principle of virtual work and it is discretized into a system of ordinary differential equations by Ritz method. Static analysis is performed in parametrical domain, assuming the magnitude of the applied force as parameter, and stability of the solution is determined. The nonlinear system of equations is solved by Newton-Raphson's method. Prediction for the next point from the force-displacement curve is defined by the arc-length continuation method. Bifurcation points are found and the corresponding secondary branches with the deformed shapes are obtained and presented.

Keywords: Parametrical analysis; stability; continuation method; bifurcation points

1. Introduction

Curved beams are structural elements with variety of applications among engineering constructions. Curved beams have application in modern bridges, they are also used in the design of light-weight roof structures or in composite components of engineering structures, like helicopter blades or wind turbine blades. The increasing use of curved beams demands accurate mathematical models to perform their analysis and to understand their behavior.

The most popular approach for modeling curved structures is by the finite element method. Majority of the research is based on straight beam elements. This approach is sufficiently accurate for slender curved beams, for which the product of the initial curvature and the height of the beam is much smaller than unity. When this product is not small, the strains of curved beams are much different than the strains of straight beams [1]. The circumferential strain varies linearly with the distance from the center of the cross section for straight beams, but does not vary linearly for curved beams. Thus, additional considerations should be taken into account for achieving better mathematical models of curved beams.

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