THE MODELING OF ARCH STRUCTURES

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Abstract: A numerical model based on exact arch finite elements with six degrees of freedom for structural analysis of arched girders is presented in this paper. This finite element is exact in the sense that it gives the exact result for a mesh of arbitrary density in the arch of constant curvature loaded in nodes. Introducing deformation characteristics and characteristics of materials into the system of three differential equations of equilibrium of the second order for the arch element, the differential formulation of arched girder is obtained. Each node unit displacement is associated with three basis functions, resulting in 18 algebraic-trigonometric basis functions in one finite element. Based on thus obtained basis functions, the field of displacements (deformations) is described, and by the minimization of potential energy functionals, the exact stiffness matrix of girder element of constant curvature is derived. By using stiffness matrix obtained in this way, it is possible to completely eliminate shear and membrane locking effects in the arch element. In that, the joint influence of bending, shear and contribution of longitudinal forces is included. Examples of arch structures in a plane were analyzed using the created numerical model for characteristic cases of loading and different support conditions.

Key words: arch finite elements, stiffness matrix, shear locking effect, membrane locking effect, trigonometric basis functions.

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