A new Hamiltonian global nodal position finite element method for dynamics analysis of submarine cables

***Hang Zhou[1,2], Xue Yan[1,2], Dean Hu[1,2] and Xu Han[1,2,3]**

[1]State Key Laboratory of Advanced Design and Manufacturing for Vehicle Body, Hunan University, Changsha 410082, P. R. China

[2]Key Laboratory of Advanced Design and Simulation Techniques for Special Equipment, Ministry of Education, Hunan University, Changsha 410082, P. R. China

[3] School of Mechanical Engineering, Hebei University of Technology, Tianjin 300401, P. R. China

*Presenting author: zhouhang@hnu.edu.cn

†Corresponding author: hudean@ hnu.edu.cn

Abstract

Submarine cables play an important role in ocean engineering and underwater exploration, such as transmitting signals and providing power to the remotely operated vehicles(ROVs) system. Considering that the state of submarine cables will affect the work of the remotely operated vehicles(ROVs) system, various approaches have been used to study the dynamics of submarine cables. However, most methods ignore the bending deformation of submarine cables which will affect the accuracy and efficiency. Especially for the submarine cable with small diameter, it is easy to bend in the process of movement.

This paper proposed a new Hamiltonian global nodal position finite element method to address the influence of bending deformation on submarine cable motions. The new global nodal position finite element discrete formulation is derived by Hamiltonian theory and Euler-Bernoulli beam theory with full expression of global stiffness matrices considering the bending deformation of submarine cables. Second-order Symplectic difference algorithm is built for numerical solution to verify the proposed method. Five-point Gauss-Legendre quadrature formulate is applied to calculate the hydrodynamic forces. The numerical accuracy and efficiency of the proposed method are validated by the Freefall cantilever test of the submarine cable, the towing test of submarine cable with lumped mass, the motion simulation of the submarine cable connected to the ROV and steady straight tow. Compared with the existing Hamiltonian nodal position finite element method [1], the proposed method is widely applicable. Especially for the elastic cable, the proposed method can also describe its motion well. All validations and comparisons indicate that the proposed method is highly accurate and efficient.

Keywords: Submarine cable dynamics, Global nodal position finite element method, Hamiltonian theory, Euler-Bernoulli beam theory, Second-order Sympectic difference algorithm

Reference:

[1] Ding, H., Yin, X., Zhu, Z. H., Zhang, L. J. C. i. N. S. & Simulation, N. A high

accurate hamiltonian nodal position finite element method for spatial cable structures undergoing long-term large overall motion. **70**, 203-222 (2019).