CFD-Based Flow Characteristics and Scale Effects of Multi-Lane Wide Submerged Floating Tunnel Tubes: Postprint

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Abstract

To meet traffic demands, submerged floating tunnel tubes should be designed with large-scale multi-lane wide cross-sections. Ocean currents represent the primary environmental loads encountered during both construction and operation phases. The flow characteristics of wide cross-sections under ocean current action, as well as size effects in scale model tests or numerical simulations, warrant significant attention. This study investigates three types of wide cross-sections designed for two-way eight lanes—elliptical, round-ended, and octagonal—using a circular cross-section as a reference. A two-dimensional numerical model under unsteady flow conditions was established using CFD software Fluent. The complex flow-around characteristics of wide cross-sections with different shapes and scale ratios under uniform flow were examined; relationship diagrams between flow velocity and the amplitude of lift coefficient, mean drag coefficient, and amplitude of moment coefficient were established for various cross-sections; time-history curves of three-component force coefficients were obtained under different scale ratios; and vorticity contours within the stable period were presented. The results demonstrate that: when flow velocity increases, the three-component force coefficients of wide cross-sections exhibit minimal variation, whereas the drag and lift coefficients of circular cross-sections decrease significantly; among the three wide cross-sections, the octagonal section exhibits the maximum lift coefficient, drag coefficient, and moment coefficient, along with the minimum vortex shedding frequency, while the elliptical section displays the opposite characteristics; the three-component force coefficients show varying degrees of differences across different scale ratios for various wide cross-sections, necessitating consideration of size effect influences; wake vortex shedding exerts a certain influence on the three-component forces acting on the structure, and the drag coefficient correlates with wake vortex strength and separation points in the vorticity contours.

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