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Displacement response of submerged floating tunnel tube due to single moving load

ZHANG Yuan[a,b], DONG Man-sheng[a,b,*], DING Hao[a], YANG Long-chang[b]

[a]*China Merchants Chongqing Communications Technology Research&Design Institute Co.,Ltd, Chongqing 400067, P.R.China*
[b]*School of Transportation Engineering, Hefei University of Technology, Hefei 230009, P.R.China*

Abstract

In this paper, the submerged floating tunnel(SFT) tube is simplified as an elastically supported beam with two springs and dampings at each end. The kinematic equation for SFT tube under a single moving load is established to investigate kinematic problems. By using the Galerkin method, the kinematic equation at the mid-span section of SFT tube can be solved, and the mid-span displacement of SFT tube is gained by numerical simulation method. The influence of anchor stiffness, moving load and moving velocity on SFT tube can be learned about by analyzing the simulation results. The present results indicate that the anchor stiffness plays a significant role in influencing the SFT tube's displacement. At the same time, it also decides the vibration frequency of SFT tube. Moreover, the magnitude and velocity of the single moving load can also have an obvious impact on the tube's mid-span displacement. The research results would provide as a theoretical reference for further study and futural construction of SFT.

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Keywords: submerged floating tunnel; single moving load; displacement response; parameter design; numerical simulation

1. Introduction

The submerged floating tunnel(SFT) has provided a new traffic method for water crossing. It maintains the balance and stability by a combined effect of deadweight, buoyancy and anchoring system. As a economy and eco-friendly structure, the SFT has a very broad prospect in application and that can be the reason why it has attracted so many researchers to study.

*Corresponding author.Tel.: +86-181-1967-0189;
Email address: dongms@hfut.edu.cn

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Since last century, many foreign researchers have carried out research study on SFT. The dynamic response of different types SFT under effect of seismic force and wave force has been researched by Brancaleoni [1] for finding out the environment effect on SFT. By finite element modeling and analysis with Navier-Stokes equation, Remseth [2] adopted numerical simulation method to study fluid/structure interaction and dynamic response of SFT. Entering the 21st century, the researched have diversified. Sato [3] considered that the SFT can be regarded as a beam on discrete elastic supports if its tension legs are separately spaced along its length and the elasticity of the tension legs is taken into consideration. Lu [4] simulated the slack/taut alternate state of mooring tethers by bilinear oscillator and analyzed effect of buoyancy-weight ratio and inclined mooring angle on SFT dynamic response for preventing the occurrence of tether slacking and snap force. The wave force characteristics acting on the SFT with different structure and size has been investigated by Kunisu [5] , and Morison's equation was applied to evaluate the role of drag force. Xiang took the coupling vibration of SFT tube and cable into consideration, and studied nonlinear Vortex-induced dynamic response by discussing mid-span displacement and time curves under different working conditions and parameters. In these years, a lot of researchers have put more focus on dynamic response of SFT under moving loads. Such as Tariverdilo [7] , who has proposed that the dynamic response caused by moving loads can be controlled by increasing anchor stiffness.

On the base of the research by Yang [8] and combining with structural characteristics of SFT, the SFT tube is simplified as an elastically supported beam with two springs and dampings at each end. The kinematic equation for SFT tube under a single moving load is established to investigate kinematic problems in this paper. By using the Galerkin method, the kinematic equation at the mid-span section of SFT tube can be solved, and the mid-span displacement of SFT tube is gained by numerical simulation method. The influence of anchor stiffness, moving load and moving velocity on SFT tube can be learned about by analyzing the simulation results.

2. Physical structure and simplified model

An innovative concept design of SFT is proposed in this paper, which is called 'biplanar mooring SFT', see Fig.1. The traditional SFT structure system includes tube, tension legs, tube section connecting device, anchoring system, etc. These anchoring systems are usually set symmetrically in the plane perpendicular to tunnel axis with equal distances, consisting of 2 or 4 anchor cables or tension legs on each plane. The new one has been improved to conquer the disadvantages of traditional structure. It includes joint structures between tubes, tube segments and two sets of symmetric anchor structures set respectively to the tube at the flank of the joint. The new one could not only have the advantages of foregoing SFT structure, but also avoid its possible disadvantages. The precast segmental construction technique is usually used for SFT building because the length of SFT can be hundreds meters or even kilometers. After carried by barges to the designated place, these precast tube sections are installed in situ underwater. One of them is discussed and analyzed in the paper.

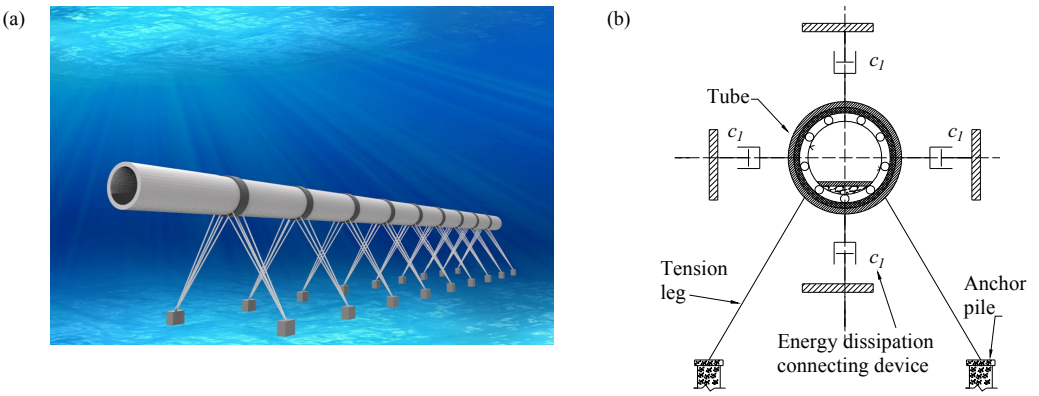

Fig.1. The non-simplified model of SFT.(a)The schematic diagram of SFT model and (b)The schematic cross section of SFT on the support.