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Research Progress and Outlook on Critical Characteristics of Submerged Floating Tunnels

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Abstract

As a new traffic structural form, submerged floating tunnels are still in the initial engineering stage. To focus on the research direction as soon as possible, it is necessary to conclude and make contrastive analysis on the research results of submerged floating tunnels. The section forms, the actions of wave force and ocean current force, structural dynamic response and anchor cable stability etc of submerged floating tunnels are selected to serve as the critical indexes of characteristics or roles, being the main analysis object. Based on a great deal of research and investigation on scientific and technical literatures, the research methods, conclusions and consensuses etc are compared, and the research blank and development trend are analyzed. The results indicate: (1) the section forms are determined based on the circumstance of flowing water. An experimental study under large Reynolds number needs to be carried out in the future; (2) According to the actual environmental research, wave force can serve as one of the important bases for the determination of suspension depth; (3) The law of ocean current effect of submerged floating tunnels requires further empirical coefficient research, and fatigue damage also can serve as future research direction; (4) Dynamic response can concentrate on large-scale model experiment as well as the influence of traffic behavior in submerged floating tunnels under dynamic response; (5) Anchor cable stability can focus on vibration reduction method of anchor cable character parameters and semi-active or active vibration reduction control method of anchor cable itself; (6) The future research emphasis should be laid on the large-scale submerged floating tunnel model experiment in complex water area environment. The above conclusions point out the direction for the future research in the field.

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1. Introduction

In 1989, the work group of International Tunnelling Association SFT (Submerged Floating Tunnel) began to officially launch the special research on submerged floating tunnels [1]. The relevant researches about submerged floating tunnels currently focus on the dynamic analysis of anchor cable structure, the vibration response of pipes under different load effects and the influence of fluid-structure interaction on submerged floating tunnels etc. Such researches were made earliest in Europe, particularly Italy and Norway made extensive research on submerged floating tunnels, including overall design, theory of computation, design method & guide and construction method etc. Japan and America also investigated on submerged floating tunnels according to their own actual situations in conjunction with civil engineering and ocean engineering technology, and put forward 10 main research directions including section form, pipe structure and anchor cable etc. [2]

Our country is still in the initial stage in the field. Therefore, to focus on research direction as soon as possible and follow development trend, it is needed to make systematic generalization for the research achievements of submerged floating tunnels, particularly making comparison and analysis on the research progress of the critical characteristics.

2. Selection of critical indexes of characteristics or roles

Submerged floating tunnels are a kind of special underwater tunnel structure system. Compared with other types of underwater tunnels, the most evident difference is that they are “suspended” in “water”, but other underwater tunnels are “embedded underwater”, consequently forming their exceptional engineering characteristics. The research progress in submerged floating tunnels can be better facilitated only after the critical indexes or roles affecting the special engineering characteristics are analyzed and investigated.

For this purpose, the paper is based on the following principles: (1) environmental indexes or roles with less or basically no influence in other types of underwater tunnels; (2) important control parameter indexes or roles of submerged floating tunnels; (3) indexes with obvious significance on the implementation of submerged floating tunnels. Based on lots of research and investigation, the section form, wave force and ocean current force actions, structural dynamic response and anchor cable stability etc of submerged floating tunnels are selected to serve as the main analysis object.

3. Research status and analysis of critical characteristics

3.1 Section form

The section forms of submerged floating tunnels are mainly based on numerical simulation [2-4], and the obtained representative research achievements can be seen in Table 1. For the submerged floating tunnels with uniform flow or typical water area, the pressure intensity distribution of structure surface under different section forms, along with sectional resistance change and structural stability, is researched, and rational section form suggestions are raised. Compared with the above research achievements, the following research consensuses are concluded: (1) with the increase in inflow velocity, the positive, negative pressure regions of the structure surfaces are enlarged; (2) the width of incident flow surface has little influence on the distribution of pressure field around submerged floating tunnel, but has obvious impact on structural lift and drag; (3) when the aspect ratio is constant, life and drag coefficient variation: sections with obtuse angle $>$ sections without obtuse angle, size of wake zone:

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