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Research on the Layout Plan of Tether-typed Submerged Floating Tunnel

Jiajun Xiang[a], Xiaojian Pi[b], Shilun Feng[a,] *,Chen Bian[a]

[a]*Institute of Civil Engineering, Tianjin University, Tianjin 300072, China*
[b]*China Southwest Architecture Design and Research Institute Corporation, Chengdu 610084, China*

Abstract

Submerged floating tunnel as a new form of tunnel structure, has not been put into practical engineering construction, so it is necessary to conduct deep theoretical and experimental researches, and how to minimize costs while ensuring the safety of the submerged floating tunnel is a great challenge that designers face. Tether-typed(tension leg type) submerged floating tunnel is a submerged floating tunnel which suffers buoyancy greater than its weight. In the paper, under the special soil condition of the South China Sea region, the correlation of main design parameters(submerged floating tunnel length and diameter, the ratio of buoyancy and gravity, the length and space of single pile foundation) is researched based on the straight line tether-typed submerged floating tunnel with double-row single pile, single vertical tether, round section, and a series of different layout plans for tether-typed submerged floating tunnel are proposed, whose economy is evaluated from the perspective of the total amount of steel, providing reference to propose the optimal layout plan for the designers and related personnel of the tether-typed submerged floating tunnel.

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Keywords: tether-typed (tension leg type) submerged floating tunnel; design parameters; layout plans; economy evaluation

1. Introduction

Submerged floating tunnel is a new mode of transportation across straits, inland lakes and other permanent waterway facilities, called SFT for short, which can suspend at a certain depth position due to the balance of its own weight, buoyancy and support system[1,2]. Compared with the traditional structures such as bridges, seabeds or undersea tunnels, the submerged floating tunnel is fixed by the tether, so there are no large-scale mining or infrastructure work. The used floating tunnel technology has many advantages such as economic, environmental and

* Corresponding author. Tel.: +086-139-0216-4874; fax: +086-022-2740-5816.
E-mail address: shilunfeng@126.com(Shilun Feng)

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so on, thus providing an attractive and competitive option for the construction of transport facilities between lakes and straits[3,4].

Submerged floating tunnel as a new form of tunnel structure, has not been put into practical engineering construction due to various reasons, reflecting many existed technology problems to be studied and explored[5]. Researches on the submerged floating tunnel in our country are still in infancy state, which currently focus on the feasibility study and the overall concept design while a blank in most other research areas, so it is necessary to conduct deep theoretical and experimental researches for submerged floating tunnel[6].

When the buoyancy subjected by the submerged floating tunnel is large, the anchor foundation is in the state of uplift[7]. The application condition of tether-typed submerged floating tunnel is that the ratio of buoyancy and gravity is more than 1.0, that is, the floating tunnel tube tends to up, and the extra buoyancy passed to the anchor foundation through the tethers enables the tubular body suspended in water. Due to the high strength of tethers and the progress of underwater construction technologies, the arrangement of this submerged floating tunnel is flexible and adaptable, which can be built in deeper waters. So the tether-typed submerged floating tunnel is chosen as the research object in this paper[8].

Safety and construction costs are the primary issues taken into consideration by tether-typed submerged floating tunnel designers, the security of tether-typed submerged floating tunnel is directly related to whether to be accepted by users while the construction costs are related to whether to be adopted by construction department[9]. Therefore, the design principle of tether-typed submerged floating tunnel is under the premise of safety to meet the low-cost as possible. The design parameters that affect the safety and construction costs of tether-typed submerged floating tunnel are tunnel length and diameter, the ratio of buoyancy and gravity, the form and space of anchor foundation, tether layout and so on, and these parameters are not isolated, there must be some necessary connection between them. In the paper, under the special soil condition of the South China Sea region, the single pile is chosen as the anchor foundation of tether-typed submerged floating tunnel, then the correlation of main design parameters are identified and a series of different layout plans for tether-typed submerged floating tunnel are proposed, which lay a foundation for raising the best design plan and achieving the design goal “ensure security and low cost”for designers and related personnel of tether-typed submerged floating tunnel.

2. The special soil condition of the South China Sea region

The special soil condition of the South China Sea region for tether-typed submerged floating tunnel is shown as Table 1, which are 19 layers sand or clay soils with different properties; the single pile is chosen as the anchor foundation of tether-typed submerged floating tunnel, whose form is simple and load is definite. The unit skin friction capacity and unit end bearing capacity are calculated by 6.4.2—6.4.3 in API RP 2A WSD-2005, the special formulas are as follows:

1)For cohesive soils:

$$q = 9c \tag{1}$$

$$f = \alpha c \tag{2}$$

q—unit end bearing capacity, in unit of kPa; f—unit skin friction capacity, in unit of kPa; c—undrained shear strength of the soil at the point in question, in unit of kPa; α—a dimensionless factor, which is calculated by:

$$\alpha = 0.5\psi^{-0.5} \quad \psi \le 1 \tag{3}$$

$$\alpha = 0.5\psi^{-0.25} \quad \psi > 1 \tag{4}$$