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Research Article

Study on Innovative Scenario for Transportation and Lowering of 18000 Ton Caisson for Persian Gulf Bridge

Abstract

This paper aims to provide an innovative scenario for transportation and lowering installation of heavy caissons of 18000 tons for Persian Gulf Bridge. The project is supposed to be carried on in Bohal port from Hormozgan to Qeshm Island in Iran. There is a heated controversy over the suitable scenario to do the operation safely and lower the caissons correctly under sea to position them on their exact location. Due to this a comprehensive study is need to take heed all aspect of the operation. The study will include a discussion on both sides of installation and transportation and give a deep-rooted insight over the excuvation plane for the operation.

Introduction

The procedure for transportation and lowering of heavy caisson in sea in range of 15000-20000 tons are complicated scenarios. There is no clear literature in regard to this study from previous researches. The purpose of this article is to present a suitable and innovative scenario for transportation and lowering of 18000 tons caissons for Persian Gulf Bridge. Caissons will be constructed in dry dock, but due to its heavy lightweight the available floating cranes couldn't transport and install it independently. So a proper and safe scenario is presented based on a Catamaran which is proposed to be two connected barge together by a truss structure. All procedure is described related to this catamaran and illustrated for each scenario for better conception. One of the most advantages of this scenario is the decreasing of operation procedures and also increasing the safety of the operation and its accuracy. Finally a flowchart related to presented scenario is presented.

Characteristics of persian gulf bridge (iran)

Persian Gulf Bridge is proposed to connect Bohal port from Hormozgan to Qeshm Island. Transportation of its caisson will be done in a direct rout of about 5.5 km that its characteristic is shown in Table 1 and Figure 1. It should be noted that the lifting weight is very important in installation procedure and will be discussed later [1].

Study on presented scenario for transportation

Regard to transportation of heavy objects, there is two ordinary concepts:

Table 1: The caisson weight and dimensions for Persian Gulf Bridge.

	Caisson Characteristics
Length & Width (m)	35×45
Height of Pier (m)	35
Dry weight (m)	18000
Lifting weight (m)	5000
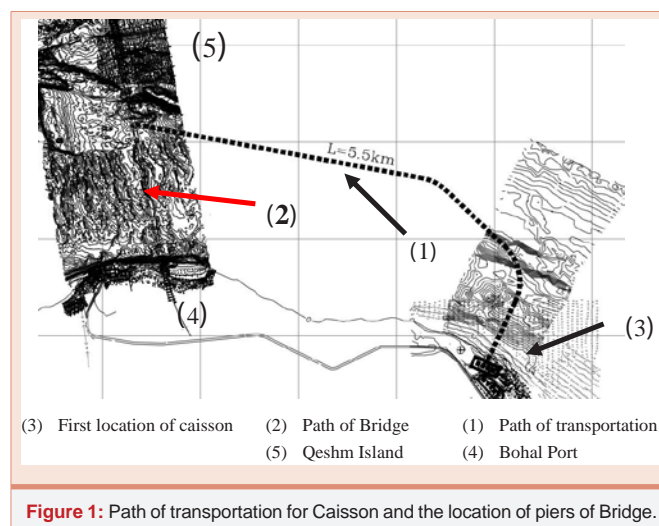
Figure 1: Path of transportation for Caisson and the location of piers of Bridge.

(3) First location of caisson (2) Path of Bridge (1) Path of transportation
(5) Qeshm Island (4) Bohal Port

a) Transportation of an object using floating Crane

b) Transportation of an object using tug

For the caisson that its dimensions and weight are very high, then these concepts couldn't be suitable and practical. In related to lifting weight of about 5000 ton and extended cross section of caisson, then there will be no practical and available crane for doing the transportation and lowering procedure. Also it could be dangerous and unsafe operation even though in a calm condition. So it's necessary to provide a situation that the hydrodynamic response and hydrostatic condition for caisson in whole of the operation be suitable, and then the caisson installed in its proper position with minimum offset. Therefore a scenario is presented here using two barges that connected with each other as a catamaran and the caisson is trapped between them. It's useful to use truss sections for connecting these two barges. Also each barge should have multi strand cable system for

lifting and lowering of the caissons in longitudinal directions. These systems should be installed in each edge of the barge. In horizontal direction it's necessary to use fenders to prevent any collision between caisson and barges. It will help the operation to be done in a safe condition.

Since the lifting weight is about 5000 ton, then it's recommended that the caisson hold with pre tension multi strand cables between two barges and whole of the system transported to the location by three tugs. For this purpose it's needed to fill a percent volume of the caisson with water in which the total pre tension in cable become:

$$W_C - B_C = T_{Cable} \qquad (1)$$

In which WC is caisson's weight, BC is buoyancy and TCable is needed pre tension. To calculating the accurate and optimum one, at first it's needed to know about the multi strand system characteristic and after that have estimation for hydrodynamic response of the system in transportation regard to percentage of filling water in caissons compartments.

Using these three tugs is necessary for increasing stability and safety of operation during transportation and also it will helps to prevent any problem in yaw degree of freedom and also in oblique incident wave. Due to this it's recommended that use a Bridle system for tugs. Using fenders help caisson to prevent swing in horizontal direction. Fatigue analysis is necessary for multi strand cables. Two other supply tug vessel may need to support the barge and caisson from aft to increase safety during transportation. The main duty of these tugs is providing sufficient tension in connecting cables between catamaran and forward tugs and also providing better stability and maneuvering for transportation operation especially in beam waves and in yaw direction [2,3]. So it has no necessarily for aft tugs to have Bridle system. It could be check from hydrodynamic analysis that these to aft tugs may omit from the operation regard to environmental of site. Schematic illustration for presented scenario for transportation is illustrated in Figure 3.

Study on presented scenario for lowering

Before executing the operation of lowering procedure, it's necessary to be moored the catamaran in the field. The configuration of mooring system will be assigned by hydrodynamic and aerodynamic analysis in coupled condition of catamaran and caisson [4]. It's recommended that not use lower than eight cable for catamaran, it will help better dynamic response and will prevent from twisting of wires in harsh condition. After that the lowering operation could be enhanced. The operation sequences can be mentioned as bellow:

1. It should be assured that the catamaran and caisson are moored in correct position and multi strand cable are properly installed.

2. The sea bed should be dredged before lowering the caisson and ready for installation.

3. GPS, Survey equipment, underwater cameras and divers be ready for installation operation. It's necessary to surveying the operation by these utilities up to 8-10 cm gap between seabed and caisson for minimum the off-track.
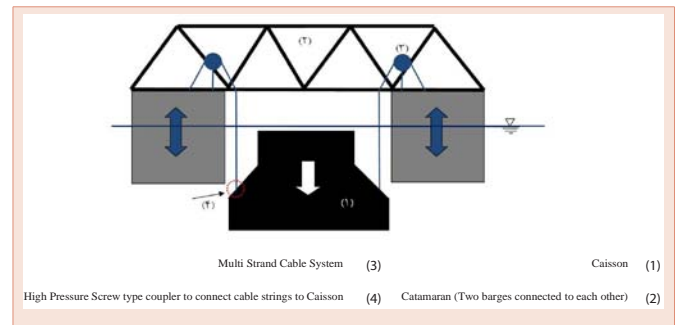

Multi Strand Cable System	(3)	Caisson	(1)
High Pressure Screw type coupler to connect cable strings to Caisson	(4)	Catamaran (Two barges connected to each other)	(2)

Figure 2: Schematic illustration for presented lowering operation scenario.

Before full submerging of caisson, the multi strand cables that connected caisson to barges should be changed its tension in a steady and easy-easy lowering operation, up to reach the proper tension as the same as lifting weight for full submerging. After full submerging, caisson will be lowered with the tension equal to lifting weight by steady speed the same as before one. It will help that caisson encountered with the minimum inertia forces during operation. The limitation criterion for the speed of lowering of caisson is very important. This will affected by the type of multi strand system, the tension on cables and the environmental conditions, e.g if the system of the cable is based on hydraulic then due to high efficiency, speed of lowering of caisson in ideal condition (Calm water) could be up to 10 m/hr. if the speed increase up, then the affection of current and wave can exert notable periodical momentum on caisson and subsequently on the cable system. This will run into the operation in serious problem such as high off-track and fatigue problem. Finally the maximum speed of lowering of the caisson could be recommended not be higher than [4,5]:

$$V_{Lift} < 10 \left[\frac{m}{h} \right] \qquad (2)$$

For better illustration of presented scenario view of the operation is depicted in Figure 2 schematically.

In general the capacity of each multi strand system should be defined based on lifting weight. Since, the operation is better to be done in a steady speed as discussed before. So the compartments of caisson after the full submergence will be filled completely. Then regard to Eq. (1) in full submergence condition for the lowering operation should be defined as $W_C - B_C = Lift_W$. In which $Lift_W$ is lifting weight. Finally the required tensions for each multi strand system define as [6]:

$$T_S = \frac{Lift_W}{n} \qquad (3)$$

Here TS required tension for each multi strand system and n is the number of system. For better conception and number of required system for installation operation regard to Persian Gulf Bridge caisson characteristic (Table 1) is shown in Table 2.

Conclusion

In this article an innovative scenario is recommended for transportation and lowering operation for the 18000 ton caisson of Persian Gulf Bridge. Regard to scenarios that discussed in this study, it
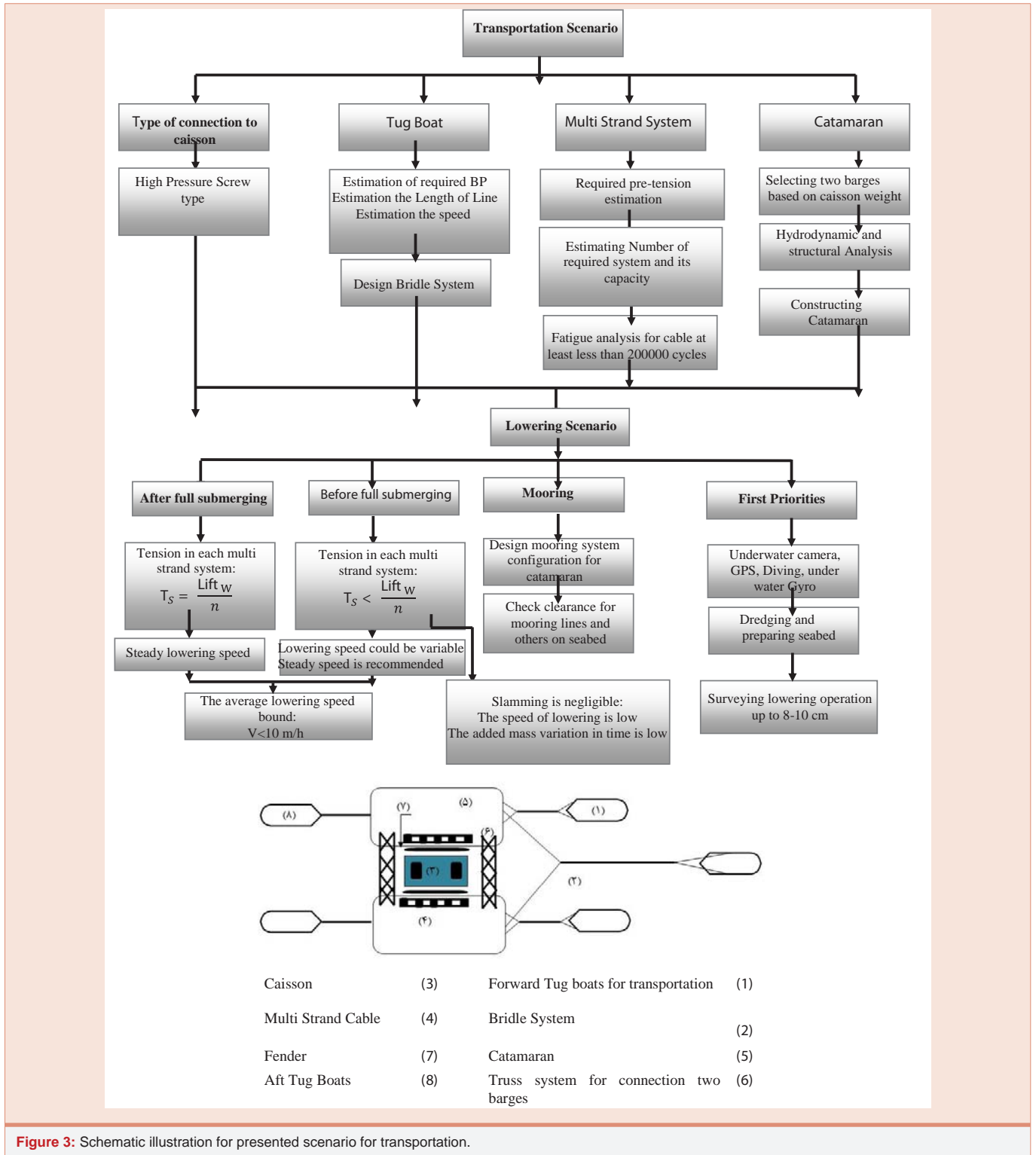
Figure 3: Schematic illustration for presented scenario for transportation.

Table 2: Characteristics and number of required cable system for installation operation.

	Lifting weight (ton)	Type of system	Type of connection	Number	Capacity for each strand (ton)	Weight of each system (kg)	Max lowering speed (m/h)
Caisson	5000	Hydraulic	Strand (SLU1)	16 Strand	320	1028	V<10
²Strand Lift Unit.							

is found that it could not only decrease the time of operation, but also have notable safety and accuracy especially in lowering procedure. This would help to minimum the off track of the settlement of caisson. For the better conception of the recommended scenarios, schematic illustration shown and finally a flowchart presented to summarize the operation procedures and its notes.

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