

The Analysis of Construction Related to Gravity Caisson Wharf

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Abstract: In this paper, firstly, the characteristics of gravity caisson wharf construction are introduced. And then, three aspects of gravity caisson wharf construction are analyzed: The first aspect is excavation of foundation trench and throwing riprap into foundation trench; The second aspect is construction of caisson; The third aspect is construction of superstructure. Construction of caisson involves the production facilities of caisson, manufacturing, launching, hauling, transporting, placing, filling and backfilling caisson, and filter material in joints between caissons etc.

Keywords: Gravity caisson wharf; Construction; Analysis

1. Introduction

Reinforced concrete caisson wharf is one of the commonly used structure of gravity type wharf. It is mainly used for rock foundation, or the non rock foundation with a better bearing stratum. With the development of the soft soil foundation reinforcement technology, it is also built on the soft foundation dealt with the cement system mixing method, but the cost of that is high[1].

The gravity type caisson construction generally has the following characteristics[2-3]: On the one hand, it needs slide type prefabricated field, dry dock, floating dock or large crane that are caisson production facilities or facilities used for launching caisson, and engineering ship; In the route of hauling caisson, there must be enough water depth, and at the same time the sea surface should be relatively stable; It should be noted that the caisson can be made with precast concrete, so the feasibility of the construction is higher; On the other hand, as the production sites can be selected in the construction of a favorable place, the placement job on the spot just needs a relatively short time; In addition, caisson requires a lot of internal filling material.

2. The Construction of Gravity Caisson Wharf

2.1. Excavation of foundation trench and throwing riprap into foundation trench

1) Excavation of foundation trench

Engineering ship for trench excavation is mainly clamshell dredger. But, sometimes, according to engineering quantity and size of construction, bucket dredger and suction dredger are also used[4]. The following aspects should be paid attention to in trench excavation: On the one hand, for trench excavation near existing structures, it should take into account of stability of structures. In

addition, the choice of engineering ships must also take this into account. Usually, smaller clamshell dredger should be used when trench excavation is near existing structures. The excavation of the foundation trench of quay wall will affect the surrounding structures. In advance, the allowable range and the treatment method of over-excavation should be put forward. In principle, the harmful over-excavation should be backfilled with high quality sand. On the other hand, trench excavation depth is uncertain when it is for the purpose of removing the weak foundation and improvement of foundation. In this kind of situation, the results of excavation should be combined with the design of construction, so that requires strict construction management. In addition, floating mud may flow into trench excavated or slope may collapse in the period between trench excavation finished and input of replacement material. So the trench should be filled up with replacement material as quickly as possible after the excavation finished. If the trench has some sludge, the sludge, in principle, should be removed with appropriate dredger etc.

2) Throwing riprap into foundation trench

The following aspects should be paid attention to in the process of throwing riprap into foundation trench: On the one hand, the riprap texture should be hard enough and has toughness, and the shape of riprap can make riprap meshed with each other. So granite and andesite etc. are suitable to be used as riprap. In addition, If superior quality stone is insufficient, limestone, sandstone, slag etc. can be placed in the central part of riprap foundation where the stone is less susceptible to wave and tidal currents. Installation of main structure of caisson wharf will cause the settlement in riprap layer, so the height of the top surface of riprap layer should be higher than the calculated value. The excess is called anticipated settlement, whose quantity can be determined according to the actual

situation of the construction scene. On the other hand, due to riprap sunk into foundation and being lost and other reasons, the addition of excess part of riprap should be taken into account. The excess is called wastage, whose quantity is affected by the degree of soft and hard of the surface of foundation, wave condition, water flows, throwing and filling method etc. Its quantity should be determined according to the actual situation of the construction scene[5].

2.2. Construction of caisson

1) The production facilities of caisson

Equipment of caisson precasting yard generally includes material storage equipment(e.g. cement storage, sand and stone storage yard, template stack etc.), manufacturing equipment(e.g. concrete factory, concrete pump, sliding chute etc.), equipment for launching caisson(e.g. sliding chutes, dry dock, floating dock etc.), transport equipment(e.g. crane, belt conveyor, truck etc.), power equipment(e.g. substation), accessory equipment(e.g. laboratory, staff office etc.).

In addition, the layout of caisson precasting yard and equipment capacity have great impact on construction schedule. In order to ensure that the equipment has higher efficiency, caisson precasting yard should be designed in accordance with the requirements of convenient operation.

2) The manufacture of caisson

Caisson is usually manufactured in the dry dock and slipway. If there is a large crane ship, caisson can also be manufactured on bank revetment and be hung up and transported. Floating dock can be used for manufacturing caisson in the case of the small scale production of caisson.

Each caisson construction stage can be slightly separated in mass production of caisson, and caisson construction is in the way of assembly line, which can increase efficiency. This requires the effective use of mechanical equipment, templates, scaffold, etc. and appropriate arrangement of working personnel. Therefore, normally, the details of each construction process should be studied in the organization of construction plan, which construction management is based on.

It should be noted that on the one hand, the caisson production platform is used as bottom template, and templates of other sides are set up in the manufacture of caisson. Therefore, the caisson production platform must be flat surface and can withstand the load of template and scaffold. In addition, because the production platform and caisson concrete floor will bond together, kraft paper and asphalt felt are usually used to separated them. And the felt can be covered with sand to avoid asphalt and concrete bonding together due to heat of hydration from concrete. On the other hand, the height of layered pouring of caisson not only has an influence on precast con-

struction progress, but also has an influence on the difficulty of concrete construction, turnover use of templates. In addition, the steel bars of caisson may be in danger of corrosion after caisson placed in the seawater. So vibrating of concrete of the steel bar protective layer, disposing construction joint, removing cork etc. should be in particularly careful construction.

3) The launch of caisson

The launch of caisson is in preparation when prescribed maintenance of caisson concrete is finished. The methods of launching caisson are different due to different structures of prefabricated field. On the one hand, in slide type prefabricated field, the wooden chute is either coated with grease or installed with inclined frame vehicle, roller wheels, and caisson is launched. In dry dock type prefabricated field, water is injected into dock to make caisson floated, and then caisson is pulled out. This method needs to check the stability of floating and pulling caisson in order to avoid overturning. On the other hand, caisson set on quay wall can be hung out and put in the water by the use of crane ship, or be hung out, maintaining the state, and then be hauled to the place of setting caisson etc.

4) Hauling, transporting and placing caisson

There are several methods of hauling caisson: The first method is using peripheral steel wire to twine around the part above floating core line of caisson, and then use towing cable to haul caisson. The second method is that in advance, iron anchors for hauling caisson are embedded in the side wall of caisson, and towing cable can be tied with iron anchors, so caisson can be hauled. The third method is using pusher barge to push caisson. But it should be noted that large caisson would interfere with the sight of the top push barge due to high freeboard of large caisson. The fourth method is using hanging method. Caisson can be hung up by the use of crane ship. In this state, crane ship is towed away, and caisson is to be carried to the setting place and to be placed.

Caisson transporting means that for the port without caisson precasting yard, sometimes, caisson needs to be manufactured in other ports ,and then to be hauled a long sea distance to the port. It should be noted that caisson may sink when many sea water enters caisson due to sea waves. So it is necessary to investigate the situation of meteorology and ocean hydrology. Prevention cap of caisson and drainage pumps are also needed when it is necessary. In addition, it needs to be ensured that there is a sheltered place in midway under storm weather condition.

Caisson can be placed according to the following methods[6]. One method is that in the case of calm sea conditions, if installation of super large caisson is dealt with crane ship, wave has little effect on that. The location of caisson can be freely shifted by the operation of windlass, which can bring pretty good installation accuracy. Thick-

ness of cable, method of tying cable and arrangement of anchor etc. depend on the size of caisson, the capacity and number of windlass. After caisson into a predetermined position, caisson can be set and fixed by the way of irrigation from irrigation valve opened, or siphon pipe, irrigation pump etc. Another method is that in the case of sea conditions unstable, caisson can be carried to near the scheduled installation location by the use of tugboat or pusher barge, and then caisson can be towed to predetermined position by both anchorage cable tied on caisson, which is controlled by winch, and caisson shaking along with wave. Then caisson can be set and fixed by the way of irrigation from irrigation valve opened. It should be noted that caisson being installed should be filled with the first time water to make it sink almost to the top of the top of the rubble bed. At this time, the caisson has a appropriate distance beyond the alignment of other caisson installed. Then the caisson floats backwards with the help of the swell effect. Until the caisson being in consistent with the alignment of other caissons installed, the caisson can be filled with the second time water to make it sink completely. If the timing of irrigation is not well controlled, the caisson will float backwards excessively. At this time, the caisson needs to be pumped water out by using water pump, to make the caisson itself float up. Then repeat the above steps. Therefore, the operation of steel wire cable and irrigation valve needs to be skilled and coordinated[7]. In addition, The installation of the first caisson generally is not very accurate. it should be pumped water out, and then floating, and be installed again after the second caisson installed completely[8].

5) Filling and backfilling caisson

Caisson is generally filled with sand, gravel, slag or stone, etc. It should be noted that the height of top surface of filling material in each box of caisson should be gradually increased at the same speed. The reason is that this can avoid caisson wall strength damaged and caisson tilted. The transport ship with grab is often used as engineering ship.

Backfilling sandy soil is generally after the construction of backfilling block. It should be noted that if backfilled sandy soil falls into the gap of backfilled block, the quay pavement subsidence will be caused by that. Therefore, taking appropriate material gradation can avoid larger gap. If possible, cushion for preventing sandy soil can be laid on the surface of backfilled block[9].

6) Filter material in joints between caissons

If there is no riprap mound behind caisson and the butt joint type of filter cavity structure is used in joints between caissons, gravel and sand in the order of thickness degree should be successively set into cavity.

2.3. Construction of superstructure

The part of pouring concrete of superstructure is always in the range of tide changing. Therefore, the construction

of pouring concrete of superstructure must be waited until low tide happening in the port where a large tidal changing will happen throughout a year. In addition, the order of pouring superstructure is generally discontinuous by deviding the pouring part into several sections, which is beneficial to the template turnover etc[10].

3. Conclusions

(1) The most of gravity caisson wharf engineering construction site is on the sea. There are a number of characteristics in gravity caisson wharf engineering construction, but almost every characteristic is derived from the characteristic of the construction site on the sea.

(2) The use of engineering ships and the treatment method of over-excavation should be considered in excavation of foundation trench. And the excavation construction should be combined with the design of that. The riprap texture should be hard enough and has toughness, and the shape of riprap can make riprap meshed with each other. The anticipated settlement and wastage should be considered in the amount of throwing riprap into foundation trench, which can be determined according to the actual situation of the construction scene.

(3) Construction of caisson involves the production facilities of caisson, manufacturing, launching, hauling, transporting, placing, filling and backfilling caisson, and filter material in joints between caissons etc. The relevant analyses have been presented in this paper.

(4) The construction of pouring concrete of superstructure must be waited until low tide happening in the port where a large tidal changing will happen throughout a year. In addition, the order of pouring superstructure is generally discontinuous by dividing the pouring part into several sections, which is beneficial to the template turnover etc.

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