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MODULAR CONSTRUCTION TECHNOLOGY FOR LARGE-SCALE OFFSHORE ARTIFICIAL FLOATING PLATFORMS

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ABSTRACT

Construction of large-scale offshore structure faces many difficulties, the paper introduces several feasible technologies that can be used in the construction of large-scale offshore artificial floating platforms for module transportation, platform construction, module-based construction and the offshore installation of technology. By the division of large-scale offshore structure into different modules and consideration of overall build process, an integral set of construction technology is formed.

KEYWORDS

Offshore artificial floating platform, offshore module-based construction, offshore installation, offshore construction protection.

1. INTRODUCTION

The twenty-first century is an era of marine economy, the development of which is a natural stage of human development. Based on a study, the large-scale offshore artificial floating platform will become an effective, important, and reliable method of developing ocean spaces and resources [1,2].

In this paper, modular construction technology for large-scale offshore artificial floating platforms is introduced. According to research, large-scale offshore artificial floating platforms can be modular in both design and construction [3-6]. The structural modules can be manufactured on land and subsequently transported to the designated sea area for installation. Depending on the type of floating module, the construction process consists of building the fixed module and suspension of the module-building technology.

2. TRANSPORTATIOIN OF LARGE-SCALE OFFSHORE ARTIFICAL FLOATING FLOATING PLATFORMS

Large-scale offshore artificial floating platforms are constructed using modules which are prefabricated on land and then transported to the designated sea area. Due to the large size of the floating platform modules, coastal areas are the best choice for prefabrication, in order to reduce transport distances over land. For large, heavy offshore structures, sea towage or barge is the only way used for transportation from the prefabrication location to the designated sea area. Compared with transportation on the sea, the land transportation is limited by prefabricated location of modules, which make it critical from the coastal area to the sea. Among the possibilities are the sliding shift method, the airbag shift method and the tablet- powered self-propelled vehicle group shift method, all of which should be considered depending on the distance from the prefabrication location to the sea area, the environment, and other factors.

The sliding shift method involves laying the module structure on a specially-built slipway that uses a pulley wheel as the carrier. Studies showed the module is towed by hydraulic pulling machine and windlass to the water [7,8]. This method is a matured technology that is capable of rapidly shifting even large modules to water with low cost. However, the limitations of the chute structure and the relation between quality distribution, module width, and effective bearing area should be considered when the module is moving over land..

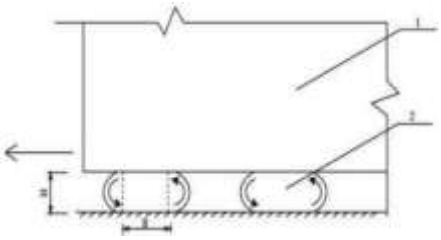

Figure 1: Sliding shift method

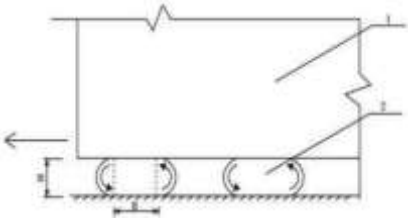

Figure 2: The airbag shift method; 1: module; 2: airbag.

According to a researcher, the airbag shift method involves positioning airbags on the bottom of the module, which is moved forward under external traction by making the gas bag scroll forward [9,10]. This method takes advantage of the flexibility of the gas bag, which deals adapts better to changes in the flatness of the ground and module. The contact between airbag and module produces a large amount of friction, which assists in moving the module and can also protect the module structure from damage arising from the concentration of stress on the bottom. After years of development, airbag shift technology has grown to be able to carry up to ten thousand tons.

The tablet-powered self-propelled vehicle group shift method transports the modules using a group of vehicles with all-wheel drive. A scholar said the heights can be freely adjusted, and they can combine together vertically or horizontally style [11]. In this method, the transportation of the modules is not affected by the structure form or building location. There is also great flexibility to adjust the carrying ability to suit the module.

To summarize the transportation method listed above, the sliding shift method requires more on the slideway due to the shape characteristics, structural characteristics and other factors of modules. Take the similarity of the manufacture method between large scale ships and floating module, it is an efficient and low-cost way to move the modules from the land to the sea by oblique berth of the existing shipbuilding base. After manufactured, the modules are moved to the water directly and towed to specified sea area, which simplifies the process of transportation and only applies to modules with floating functions. The airbag shift method takes full advantage of the flexibility of airbags and the capacity of loading is enhanced greatly combined with advanced equipment, which can be applied to the transportation of heavy complex structures. Modules can be lifted or towed to the water and barged or towed to specified sea area according to the module floating function. The tablet- powered self-propelled vehicle group shift method relies on machinery with high degree of flexibility which removes limitations caused by structure and other factors and makes it very suitable for transportation of large scale module structure on land.

3. CONSTRUCTION OF LARGE-SCALE OFFSHORE ARTIFICAL FLOATIONG PLATFORMS

Before you begin to format your paper, first write and save the content as a separate text file. Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you.

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3.1 Construction Platforms for Large-scale Offshore Artificial Floating Platforms

The construction of large-scale offshore artificial platforms is carried out using an offshore construction platform, which is a crucial part of offshore construction structures: it not only is used for storing various types of equipment and construction materials, but it is also an important facility in offshore construction itself. The successful completion of construction depends on its safe and stable resistance to waves. Construction techniques, including piling and the lateral bracing method, the steel-casing supporting method, the duct and cofferdam method, and the floating tank method are widely used.

The piling and lateral bracing method involves inserting steel pipe piles to a certain depth below the seabed using the GPS positioning measurement control on the piling ship. Then the steel pipe piles are linked by small steel pipes in a flat or oblique manner, to assemble it into a bent structure. Corbels are welded to the top of the steel pipe piles. Based on a research, the bailey beam, the steel beam, and the steel platform surface are laid on the top to make up the construction platform [12-14].

The casing supporting method involves a piling ship inserting bored steel casing piles into the seabed. Studies showed the steel casing will be the load-bearing base of the construction platform and will be developed into the final structure by the addition of steel pipes in a level or oblique style [15-18]. The difference between the level-associated plug pile method and the casing support method is that the casing acts not only as a protective casing but also as a main support structure for the platform.

The duct and cofferdam method involves erecting a steel jacket on both sides of the construction position, and then erecting the construction platform using a steel cofferdam in the middle. The floating tank method involves a steel tank being manufactured and transported by floating.
As an integral and important part of offshore construction facility, the built characteristics of platforms should coordinate with foundation construction technology as to simplify the process of construction and get a better effect, lower cost.

3.2 Foundation Construction Technology for Large- scale Offshore Artificial Floating Platforms

(1) Foundation Construction technology for the fixed modules of large-scale offshore artificial floating platforms: The fixed modules of large-scale offshore artificial floating platforms take a submerged reef as their foundation (see Figure 3). Subsea pile structures are used as supports to build the fixed part of the floating platform on top. Based on a research, there are many methods of constructing the subsea pile—such as perfusion stake foundation construction, driven-in pile foundation construction, column pile construction, open caisson foundation construction, and bell-shaped foundation construction technology, all of which are common used and reliable [19,20].

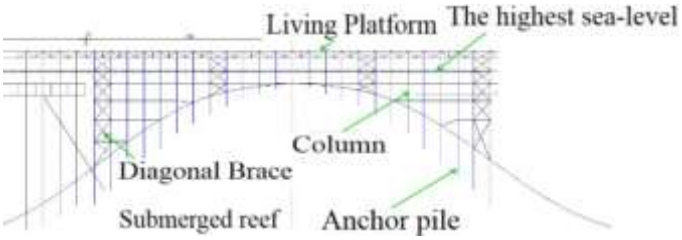

Figure 3: Fixed module of large-scale offshore artificial floating platform.

The perfusion stake foundation construction method involves drilling a hole directly at the location of pile. The steel reinforcement cage is then placed into the cavity and poured over with concrete to construct the pile. This produces the in a highly flexible manner, and the load ability of the resulting single pile is strong. The process of construction is, however, complicated and the operation requirements are strict. It is easy to cause quality faults. According to a group of scholars, the long interval of time required, the inability of the pile to bear load immediately, and the method's sensitivity to the environment are shortcomings of this approach [21-25].

Driven-in pile foundation construction is a method that involves inserting precast piles into the seabed of the designated sea area. An easily erected trestle is used in construction in nearshore and shallow areas. Based on a study, a floating piling boat is more appropriate in the construction of floating platforms far from the shore [26,27].

According to a research, column foundation construction is applicable to seabed foundation in deep water that is influenced by tides and has an undulating rock face [28,29]. Large diameter (1.5–5.8 m, thickness 10–14 cm) reinforced precast concrete, prestressed concrete, or steel columns are inserted into the base rock with a large vibration pile hammer along the guide structure. Then the tube wall is taken as the casting and the rock is drilled with an impact drill on the sea surface. The steel cages are hoisted and the concrete is poured into the cavity. Then the rocks and pipes are connected together. With the development of materials technology, the large-diameter steel pipe foundation has become a form that is suitable for use in marine construction environment, due to its excellent performance and advantages in construction.

Open caisson foundation construction places high requirements on the overall construction, as well as on the transportation, anchoring, and installation of the foundation.

(2) Foundation construction technology for the suspension module of large-scale offshore artificial floating platforms : As shown in Figure 4, the fixed modules set at the center of large-scale floating platforms are connected to the surrounding suspension modules. The suspension modules are anchored in various forms using semisubmersible offshore platforms. The modules are connected together with connectors. Thus, the anchoring of the suspension modules is an important part of the construction process. The common types of anchor foundation include gravity anchor foundations, driven-in pile foundations, suction anchor foundations, and drag anchor foundations.

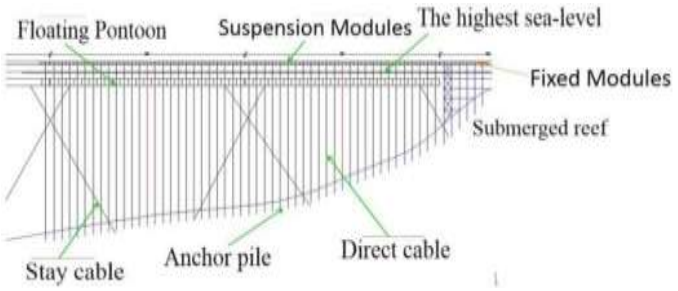

Figure 4: Suspension module of large-scale offshore artificial floating platforms.

The gravity anchor foundation mainly relies on the weight of the anchor itself to resist external forces, but also partly relies on the friction between the anchor and the soil. The driven-pile foundation is suitable for shallow sea areas. The piles are transported to the specified sea location by barge. Studies showed the piles are vertically lifted into the sea and fixed to the sea bed by tapping [30,31].

The drag anchor foundation is a high-efficiency anchor form. The anchor is buried in the seabed, and its carrying capacity is generated by the resistance to the shear forces of the seabed soil. The capacity differs according to the types of anchor and soil. The anchor is installed by anchor boats, and one installed in the seabed soil, it is dragged in the specified direction to reach the right depth of the seabed soil to generate sufficient anchoring force. Though the drag anchor provides sufficient anchoring force, it is not suitable for use in the construction of large-scale offshore platform, due to the submerged reef.

Compared with the drag anchor, the suction anchor is a more mature form of anchor foundation. The suction pile is manufactured as a cylinder with an opened bottom and a hole near the top. Water is drawn in through the hole, and the pile is buried in the seabed by means of suction. Compared with the drag anchor, the location of the suction anchor can be fixed accurately without dragging to achieve the required load. Due to the short research history of suction anchors, there is currently no uniform standard. According to a study, they are suitable for deep water, have broader soil application, are more convenient to transport and install, have a shorter construction period, have lower costs, and are reusable [32-35].

3.3 Installation of Large-scale Offshore Artificial Floating Platforms

Marine structures, such as offshore platforms, are developing in the direction of larger scale and integration. The development of lifting capacity is far behind that of module quality. Given the new demand for marine construction, the installation of marine structures has developed in two parts: floating installation and hoisting installation [36,37].

The floating installation of a platform at sea is a method that uses fixed pile foundation of a platform entirely prefabricated on land, transported by land and sea, and installed without lifting. The traditional hoisting method installs the module on piles using an offshore hoisting floating crane. Studies showed compared with hoisting installation, the floating installation solves the problems of installing very large, heavy modules, avoids cumbersome operating procedures of lifting separately (as in the traditional method), and saves times on connection debugging, and so is a method that has great advantage in the installation of fixed modules of large-scale floating platforms [38,39].

The overall floating installation method includes the floatover installation method itself (see Figure 5) and the lift-up installation method (see Figure 6). The former involves transporting the module, which has been prefabricated on land, to the sea by barge. Based on a study, having arrived at the pile location, the barge loads and sinks rapidly to install the module on the piles by buoyancy [40-43]. Using this method, the module should be aligned with the pile foundation with an anchor to protect them both from collision at the moment of cocking. The floatover installation method must be used in good weather conditions.

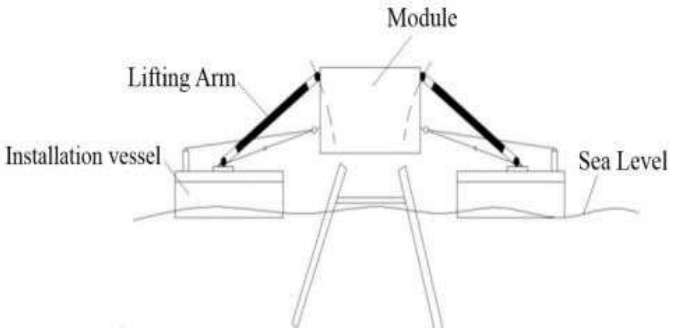

Figure 5: Floatover installation method.

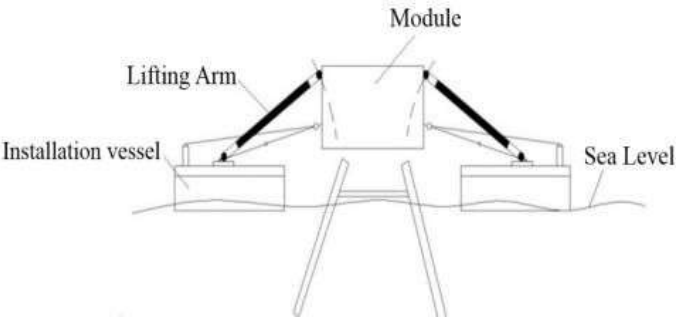

Figure 6: Lift-up installation method.

The lift-up installation method involves installation with two barges equipped with a large power hoist and a rigid lift arm. According to a researchers the module is towed near to the pile and raised by the two barges on both sides of the module, and then moved forwards to the top of pile foundation and cocked together using the rigid lift arms [44,45].All the loads are applied to the two floating barges, which makes the operation as a whole and its safety aspects difficult. The installation capacity and range of this method are limited.

4. PROTECTIVE TECHNOLOGY FOR MARINE CONSTRUCTION

The construction process of offshore platforms is complex, and the engineering project takes place in a harsh environment, in which construction technology is needed. Preventing and overcoming the impact caused by marine environment factors is crucial during the construction process.

The breakwater is an important aspect of offshore platform construction that helps deal with the harsh marine environment and to guarantee smooth conditions during the processes of construction and use. Breakwaters occur in two types: a heavy type and a light type. The former is traditionally and most commonly used, and includes berm breakwaters,

vertical wall breakwaters, and composite breakwaters. The light breakwater has been developed in recent decades with an emphasis on the surface wave energy characteristics. To answer various special needs in projects, a number of kinds of light breakwaters are being developed. According to a scholar, these include permeable breakwaters, floating breakwaters, air-jet breakwaters, and water jetting breakwaters [46].

The construction of a breakwater is affected by the construction environment, and the type chosen depends on seabed geological conditions, water depth, waves, and distance from the coast. The material use does not match the wave energy distribution in the case of the construction of traditional breakwaters such as the vertical wall breakwater and the berm breakwater. Taking into account the objective conditions, such as the distance of the artificial offshore floating platform from land, the difficulty of use and the cost of the traditional breakwater will greatly increase. The floating breakwater is an optimum structure type that can be used in deep water and in subgrade conditions where a sitting base breakwater is hard to build. Floating breakwaters can be used in the construction and use of artificial offshore platforms. The process of construction of a floating breakwater is similar to that of an artificial offshore platform, which can reduce the cost and difficulty of construction and contribute to the development of the whole project.

5. CONCLUSION

The construction of large-scale offshore floating platforms can be very complex. This paper discusses the construction process from the point of view of module transportation, building the construction platform, construction the module foundation, installing the module, and protecting the construction. The development of ocean exploitation and construction technology for marine structures—along with and further research into more efficient transportation and marine construction technology with the aim of easing the construction of large-scale offshore structure possesses great practical significance.

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