APPLICATION RESULTS OF FLOATING WORKING PLATFORM FOR UNDERWATER DRILLING

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Abstract
Nowadays, it is necessary to design and manufacture the floating working platforms for drilling underwater borehole. The paper presents the design and manufacturing plan of floating working platforms (making of iron drums) which was experimental tested to assess the stability of this platform during drilling underwater borehole. The floating platform has been designed to apply effectively in drilling underwater borehole on the sea with sallow water, waves not exceeding grade 1 and suitable equipments.

Keywords: *Floating working platform; drilling underwater borehole; underwater blasting work; experiment; stability.*

1. Introduction

In the underwater blasting work, the drilling and stuffing explosives into the borehole are often performed on a special floating platform. There are two main types of floating platforms using in drilling borehole, including specialized barge systems and floating working platforms. Abroad, research and experiment mainly refer to specialize drilling rigs and drilling equipment used in large-scale underwater blasting [2-4]. However, it is likely hard to apply in Vietnam with small-scale blasting account for majority, low water depth, mild waves, narrow borehole range, water depth fluctuate quite large, drilling equipment has a small load. In term of constructing these constructions, it is not appropriate to applies specialized barge systems bacause of low water depth not enough for operating thrust machine and costly price. Therefore, using little floating platform pushed by hand or small motor boat is entirely suitable. To ensure safety and stability during drilling process, it is necessary to have a plan for designing, manufacturing and testing floating platforms following actual construction site. This is a highly practical issue and will be presented in this article.

2. Selection and analysis

2.1. Requirements for the floating working platform and experimental regional characteristics

In the process of performing state-level science and technology tasks "Researching blasting methods to excavate into the seabed for the construction of defense, security and economic works in Vietnam's territorial waters" code ĐTĐL.CN-32/18-C in the coastal

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area of Van Don district, Quang Ninh province, there is a request to manufacture the floating working platforms for drilling underwater borehole.

Requirements for working platforms as following:

- The platform ensures safety and stability during drilling with a drill machine weight about 500-600 kg, auxiliary equipments, crews of 3-5 people, using local available materials. Due to light platform, it can be moved by local fishing boats and human power in the shallow water. Basing on these conditions: the smallest area that a drill and equipments can be placed is approximate 2 m^2, the operating space for a crews of 3-5 people is about 2-3 m^2. In addition, there is a surrounding corridor of 1-1,5 m wide, about 3 m^2. Therefore, the minimum platform area is 8m^2.

- Range of drilling area is about 50x100 m, bore density: vertical and horizontal distance between the holes are from 1 to 3 m.

The experimental area has several features as follows:

- The wave level is below grade 1;

- The water depth at the drilling area fluctuates according to the tide from 0 to 4m;

- Seabed geology is clay rock equivalent to grade 4 rock, stiffness coefficient $K_p < 3$;

- Acacia wood equivalent to group 6 is available.

2.2. Analysis of design options

First, it is necessary to study using floating materials. For the floating working platform, the chief priority is using pre-made products then assembled into floating working platforms follow the request size, low cost, short manufacturing time. We can use iron drums, plastic barrels, plastic cans, etc. There are some available types of floating materials on the market as shown in Table 1.

Table 1. Properties of commonly floating materials on the market

No	Item	Dimension (mm)	Volume (dm^3)	Weigh (kg)	Noted
1	Iron drums	Ø 600 x H 900	220	17	
2	Plastic barrels	Ø 590 x H 920	200	12	
3	Plastic cans	315 x 285 x 432	30	1,6	

Iron drums have some advantages like being impact-resistant, available on the market and can take advantage of used products. By contrast it is more weight and easy to rust, etc. For plastic drums, it is lower weight, available in the market, but does not withstand impact, breakage or puncture. Although plastic is a lower cost, it is not only less impact resistance but also small volume leads to large quantities. In addition, it is so hard to alignment. Therefore, the author chooses iron drums as floating elements.

In terms of the floating working platform structure diagram, it is often that the platform is made of a rigid frame system and covered by a board. The rigid frame system is made of trees, or shaped steel bars and wooden planks, or steel plates for the platform floor. The working platform demand is symmetrical in order to locate the drilling machine to be symmetrical follow the axes which minimize the effects of eccentric loading and limit vertical or horizontal rotation due to the dynamic loads drilling. On the basis of those requirements and actual survey, the author proposed the plan structure of the floating working platform follow Fig. 2. Overall dimensions B x L x H (m) (length x width x height) with a hole having dimensions B_k x L_k (m) (length x width) to drill through this gap. The location hole is arranged to ensure that the drilling equipment placed in the middle platform can be drilled as well.

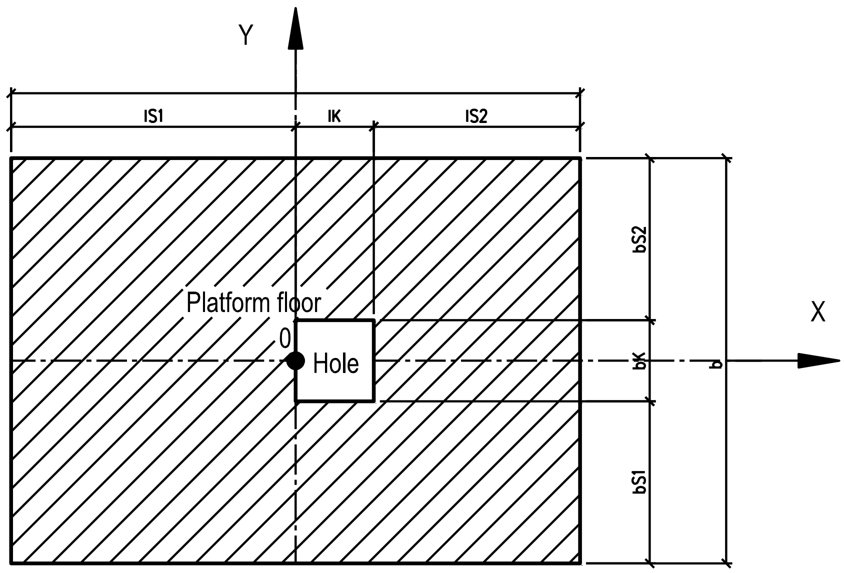

Fig. 1. Plan structure of floating working platform

Given the conditions and requirements set out above, the author chooses iron drum material as a floating material due to local availability, and can withstand rock bottom impacts at low tide. It is available acacia is equivalent to group 6 in the local, so opting the rigid frame system formated 0,5x0,5 m cells made of 10-12 cm diameter trees, the selected floor surface is 2 cm thick wooden planks, the average weight is 36 kg per m^2 platform.

2.3. Some calculations of floating working platform

To simplify the calculation, it is assumed that the working conditions of the floating working platform is perfect without waves and wind. Therefore the loads applied on structure only includes the self-weight, the load of drilling equipment and people load. Therefore, the calculation of the floating working platform for drilling underwater borehole, the floating problem is the first point that needs to be measured.

According to document [1], the theoretical basis for calculating the floating conditions presented as follows:

For floating working platform with volume V, weight G, in addition to floating on the water itself. Because of carrying equipment, it must always float on water and only part of the volume is submerged in water (in the case of positive floating), the part volume submerged in the water called V_1, $G = \gamma V_1$ satisfy the condition $G < \gamma V$, γ-weight own water. The load P that platform can carry will be determined by the formula:

$$P = \gamma V - G \tag{1}$$

The following will present the steps for calculating the parameters of the floating working platform in detail.

First, consider choosing the type of drill suitable for the geological in the experimental area. In blasting drilling, there are many types of drilling such as rotary drill, impact drill, rotary-impact drill, impact-rotary drill. Selection of drilling machine XJ-100 operating on the principle of rotation drill suitable for clay soil type with stiffness coefficient $K_p < 3$. The principle of rotary drill also helps to reduce the vibration impact of the machine on the floating platform compared to the others. The XJ-100 drilling machine P_{mk} = 490 kg. Drilling machine size 1640 x 1030 x 1440 mm. A crew of 4 people with total load P_n = 4x70 = 280 kg. Load of supported equipment P_{pt} = 100 kg. The floating materials used are the same iron drums with volume V_{ch} = 220 liters, total volume Vtp = 254 liters, drum height is H_{tp} = 90 cm, drum weight is G_{tp} = 17 kg, outer diameter is R_{tp} = 60 cm.

On the basis of such input parameters, the selecting platform plan size as follow: A hole size B_k = 0,6 m; L_k = 0,9 m in order to ensure enough space for the drill to penetrate and not touch the wooden deck, also convenient to operate in the most unfavorable case under the influence of horizontal displacement, travel corridor size B_{hl} = 1,5m; L_{hl} = 1,5m, the size of platform plan as the following formula:

$$L = L_k + 2 \cdot L_{hl} = 0,9 + 2 \cdot 1,5 = 3,9\,\mathrm{m}\,;\ B = B_k + 2 \cdot B_{hl} = 0,6 + 2 \cdot 1,5 = 3,6\,\mathrm{m}$$

Thus the floor area is $A_s = L \cdot B - L_k \cdot B_k = (3,6 \cdot 3,9 - 0,9 \cdot 0,6) = 13,5\ \mathrm{m}^2$, the self-weight of the platform is $G_s = q_s \cdot A_s = 36 \cdot 13,5 = 486\,(\mathrm{kg})$. Due to improve the safety factor in the calculation, according to current standards [5], the overload factor η_1 = 1,1 for the self-weight of the floating working platform; η_2 = 1,2 for the drilling machine and supporting equipment loads, η_3 = 1,3 for people load. The total loading effect on the floor is:

$$\sum G = G_s \cdot \eta_1 + (P_{pt} + P_{mk})\eta_2 + P_n \cdot n_3 = 486 \cdot 1{,}1 + (490 + 100) \cdot 1{,}2 + 280 \cdot 1{,}3 = 1607\,(\text{kg})$$

According to formula (1), the maximum load an iron drum can carry while it is still floating on the water is:

$$P_{tp} = \gamma \cdot V_{tp} - G_{tp} = 1000 \cdot 0{,}254 - 17 = 237\,(\text{kg}).$$

K_h - the reliability factor, following the document [5], for calculating the floating platform by iron drums system, we can get $K_h = 1{,}2$

The minimum number of drums to use is:

$$n_{tp} = \frac{K_h \sum (G + P)}{P_{tp}} = \frac{1{,}2 \cdot 1607}{237} \approx 8{,}2\,(\text{drum})$$

The number is selected 10 iron drums.

Iron drums are arranged horizontally, the maximum horizontal area of a drum as following formula:

$$S_{tp} = H_{tp} \cdot D_{tp} = 0{,}9 \cdot 0{,}6 = 0{,}54\,(\text{m}^2)$$

The condition A_s = 13,5m^2 > $n_{tp}.S_{tp}$ = 10·0,54 = 5,4 m^2 is satisfied. Thus it is possible to arrange 10 iron drums under the floating working platform with the above size to ensure the floating of the system.

In addition to ensuring floating conditions, to ensure safety when operating, it is necessary to check the stability of the working platform while the drilling machine operated which generated the dynamic load and the eccentric load due to people stand in unsymmetrical on the working platform. This point is likely hard to solve accurately by theoretical problems, so to measure fastly practical tasks, my teamwork chooses experimental methods to select the appropriate working platform for drilling borehole at the scene.

3. Results of experimental application of floating working platform for service of drilling underwater borehole

3.1. Results of experimental

With the theoretical calculation as above, this working platform is manufactured and stability and non-sinking tested when worked in reality. According to [1], to ensure safety when the machine is working, for closed floating equipment, the allowed height of the lowest point on the surface of platform compare to the water surface is [ΔH] = 0. In this case, the platform is considered to be safe while the allowed distance from point A to the water surface is [ΔH_A] = 0. To facilitate observation, arrange the height of monitoring device point B is the edge of the platform surface compared to the water surface. Thus the allowable height of point B as a follow formula:

$[\Delta H_B] + H_{hms} = 0 + 22 = 22$ cm

in which H_{hms} is the height of the platform deck system.

Diagram of the drilling machine's load and human load on the test as follows: the drill is located at the center of the floor, the supporting equipment is symmetrically placed to limit the deviated load. The position of human load on the platform change according to the actual operation of the drilling machine.

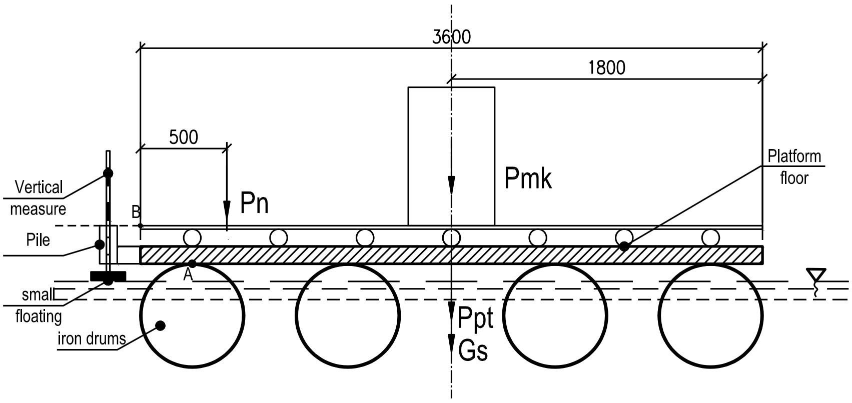

Fig. 2. Floating working platform test diagram

On the first test, the crane placed the drill at its pre-marked position in the center of the platform, a crew starts drilling machine and test drill. The rotating speed of the drill is increased gradually by 5 levels, when the drill is operating with the maximum rotating speed of 1010 (rpm). In the most adverse case, a 4-person crew stands at the same area ¼ of the platform: 0,5 m from the edge and brings about an eccentric load. The floating working platform was clearly inclined and the height of point B from the water surface was less than 22cm, so it was not safe. The test is performed three times and the results are similar, therefore the solution was to increase the number of iron drums.

On the second test, to increase the number of iron drums at each corner of the platform, meaning that adding 4 iron drums to ensure symmetry. Repeat the testing process as above. Results in the most unfavorable case as above, the inclined platform is almost negligible and then the height of point B compared to the water surface ensures $H_B > 22$ cm showing stable platform. The test continued to take place 3 different times, the results showed that the floor was stable.

Because the drilling is done in a region with almost no waves, the flow velocity is low, combined with the use of 4 anchors at 4 corners of the platform, which significantly limits the horizontal movement of the platform while drilling. Therefore, horizontal movement of the platform does not significantly affect on the drilling borohole.

The test results are shown in Table 2.

Table 2. Results of dynamic test of floating working

No	Number of iron drum	Platform size (m)	Number of drilling machine	Number of crew	Water depth (m)	Flow velocity m/s	The distance from point B to the water's edge ΔH_B (cm)	Conclusion under safety conditions
1	10	3,9x3,6	1	4	2,8	0,5	15÷30	Not satisfied
2	14	3,9x3,6	1	4	2,8	0,5	30÷40	Satisfied

3.2. Assess the applicability

After testing, the author found that the floating working platform with 14 iron drums is safe to apply in practice. This result has been used in practice to support the blasting experiment serving state-level science and technology tasks "Researching blasting methods to excavate into the seabed for the construction of defense, security and economic works in Vietnam's territorial waters" code DTĐL.CN-32/18-C. Here are some pictures at the construction site.

a) b) c)

Fig. 3. Some images in testing and application of floating working platform
a) Floating working platform for drilling underwater borehole;
b) Activities of drilling borehole from floating working platform;
c) Borehole are marked after drilling is completed

In actual construction, in order to reduce the effect of the dynamic load on the platform due to the drilling machine causing (rotating horizontally and vertically) anchoring the floor into the seabed. Using iron anchors with rope winches pulled at 4 corners of the floating platform anchored to the seabed area with reefs covered with mud about 10-30 cm thick. When the water level is greater than 1,5 m, the floating platform is moved by local fishing boats. In the case of low water, it is possible to move the platform by swimmers or wading water pull easily the anchors.

During the use of the result, many blasting projects with a large number of boreholes have been drilled successfully, which has shown the effectiveness of this floating working platform contributing to reducing construction costs, pushing fast construction progress. The results of some typical blasting projects are shown in Table 3.

Table 3. Evaluate the results of actual drilling volume

No	Number of borehole	Drilling network diagram	Average length of 1 borehole (m)	The volume of explosives in a project, kg	Fluctuating range of water depth when drilling, m	The number of shift drilling	Number of people in crew	Actual average drilling productivity m / shift	Average time of 1 drilling period , hours
1	9	Squares network a=b=1,6m	2,3	18	1-2	2,25	4	9,2	2
2	9		2,6	27	1-3	2,7	4	8,7	3
3	9		2,8	36	2-4	4,5	4	5,6	4

In the construction work, to ensure safety and save travel costs, while blasting, the floating working platform is pulled to a safe place with a distance determined according to the regulation dangerous conditions puncturing floating equipment when placing explosive at the bottom of water [6]:

$$R = K_{vt} \frac{\sqrt{k_{TNT}.Q}}{\sqrt[3]{\delta}} \text{ , m} \quad (2)$$

in which K_{vt} - coefficient depends on the ship-crust, when just causing the ship strongly oscillate K_{vt} = 1,5; k_{TNT} - TNT's equivalent of explosive, when using TNT, k_{TNT} =1; δ - thickness of floating equipment in cm; Q - mass of explosives, kg.

In the case of Q = 36 kg of explosives and an iron drums thickness of 0.1 cm, R = 19 m. To ensure absolute safety as proposed by the blasting experts, it is necessary to move the floating platform 40-50 m away from the edge of the explosion site.

In fact, when blasting, floating working platform only fluctuated follow the water wave caused by the blasting. The floating platform, drilling machine is stable and safe.

4. Conclusions and proposal

4.1. Conclusion

Experimental results of using a floating working platform size 3,9x3,6 (m) and floating element as a 220 liter iron drum, serving the drilling underwater borehole in shallow water with water depth below 4 m, the wave is lower grade 1, XJ-100 drilling machine with a self-weight P_{mk} = 490 kg, the seabed is grade 4 rock, stiffness coefficient k_p < 3. Therefore, it is possible to use this result to develop a plan to design and manufacture working platforms with the same load and working conditions, ensuring safety and stability during drilling.

4.2. Proposal

Due to the limited time and range of the paper, the author could not measure all issues such as floating working platform anchors, move the platform when the water depth > 1,5 m to ensure stability when the drilling machine is working... The author hopes to receive comments in order to continue researching more completely.

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KẾT QUẢ ỨNG DỤNG SÀN CÔNG TÁC NỔI PHỤC VỤ KHOAN LỖ MÌN DƯỚI NƯỚC

Tóm tắt: *Hiện nay, việc thiết kế và chế tạo sàn công tác nổi phục vụ việc khoan lỗ mìn dưới nước là cần thiết và có ý nghĩa thực tiễn cao trong nâng cao hiệu quả thi công và tiết kiệm chi phí. Bài báo trình bày phương án thiết kế và chế tạo sàn công tác nổi được cấu tạo từ các thùng phuy sắt, kết hợp với thử nghiệm thực tế để đánh giá tính ổn định của sàn này trong quá trình khoan lỗ mìn dưới nước. Kết quả ứng dụng sàn công tác nổi đã được chế tạo để áp dụng hiệu quả trong thực tế khoan lỗ mìn trên biển có chiều sâu nước nhỏ, sóng biển không quá cấp 1, thiết bị thi công phù hợp.*

Từ khóa: Sàn công tác nổi; khoan lỗ mìn dưới nước; công tác nổ dưới nước; thử nghiệm; độ ổn định.

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