

Study on Simulation Experiment of the Force of Floating Dock during Off-loading Based on ANSYS

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Abstract—In order to know the structure stress and deformation of floating dock during off-loading, the study on simulation experiment of the force of floating dock during off-loading based on ANSYS is carried out. The simulation experiment with ANSYS can be used to research the distribution of the structure stress and deformation of floating dock during off-loading. 11 typical load conditions are chosen to simulate the structure stress and deformation of floating dock during off-loading a bulk cargo ship.

Keywords—floating dock; off-loading; stress and deformation; simulation experiment; ANSYS

I. INTRODUCTION

Flat ground shipbuilding mainly uses floating dock to off-load the ships to launch water. During off-loading, various loads such as the dead weight of the floating dock, the weight of the launching vessel, the weight of the ballast water, and the buoyancy pose great challenges to the floating dock structure to be loaded, so it is necessary to study the distribution rules of stress and deformation of floating dock during off-loading to ensure safe off-loading, the analysis of the conclusions from the engineering application, is of great significance [1-2].

In this paper, "simulation experiment of the force of floating dock during off-loading based on ANSYS" is designed. It is helpful to solve the practical engineering problems by incorporating ANSYS simulation into the force experiment of floating dock.

II. FORCE ANALYSIS OF FLOATING DOCK DURING OFF-LOADING

In the process of transplanting the ship to the floating dock, it is required that the slideway on the floating dock deck and the shore slide to maintain the same horizontal line, that is to say, the floating dock always maintains a specific suitable floating state throughout the off-loading process. This needs to be achieved by continuously adjusting the volume of ballast tanks in the floating docks [3]. Off-loading diagram shown in Figure 1. In this process, the floating dock is mainly affected by the buoyancy, the weight of the empty ship, the weight of the ballast water, and the weight of the launching ship on the floating dock [4]. Figure 2 shows the stress analysis of floating dock during the off-loading process.

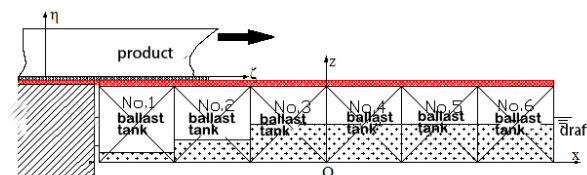


FIGURE I. OFF-LOADING DIAGRAM

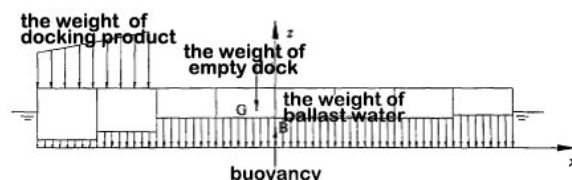


FIGURE II. THE STRESS ANALYSIS OF FLOATING DOCK DURING THE OFF-LOADING

III. SIMULATION EXPERIMENT MODEL

A. Model Analysis

This experiment is aimed at the floating dock of 22,000t lifting force, and analyzes the structural stress and deformation during the off-loading process. The main parameters are: floating dock overall length 206.38m, width 48.6m, interior width 39.6m, top deck height 16m, pontoon height 4.45m, design draft 4m, maximum sink depth 14.15m, rib distance 0.71m and empty floating dock weight 10580t.

The floating dock body consists of a continuous bottom pontoon and two side dock walls. The floating dock is laterally divided into four water ballast tanks on the left, middle, right, and right sides by one watertight mid-longitudinal bulkhead and two watertight longitudinal bulkheads, and it is divided into 6 sections in the longitudinal direction by the bow transom plate, the stern transom plate and 5 watertight transverse bulkheads, that is, a total of 24 ballast tanks. The left and starboard ballast tanks of the pontoon extend all the way to the safety deck, as shown in Figure 3.

B. Modeling and Grid Generation

Since the floating dock is basically a bilaterally symmetrical structure along the mid-longitudinal section, the model is built in half, but care should be taken to halve the size of the slab and skeleton structure in the mid-section. Modeling approach using bottom-up approach, using the command

stream input form [5]. The established geometric model is shown in Figure 4.

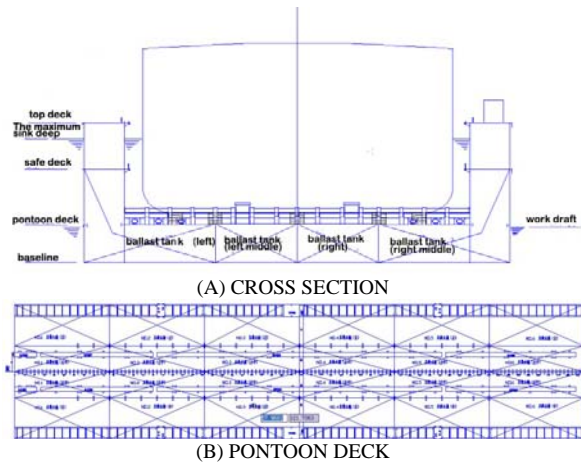


FIGURE III. FLOATING DOCK LAYOUT

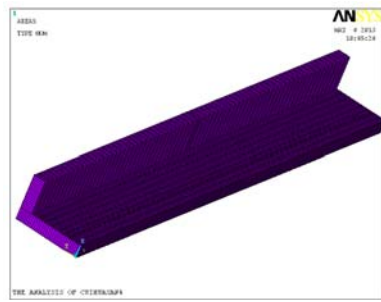


FIGURE IV. FLOATING DOCK GEOMETRY MODEL

Once the geometry model is built, it begins to mesh it. The main use of two types of units: shell63 is mainly used to simulate the board and beam188 is mainly used to simulate the various skeletons, girders, the nature of the material is mainly defined as linear elastic material, isotropic and other material properties, the elastic modulus 2.06×10^5 , Poisson's ratio 0.3, density $7.85 \times 10^3 \text{ kg/m}^3$. Try to use grid mapping grid. Grid size is generally: horizontal, taken vertical according to vertical spacing, and taken longitudinally according to the rib spacing as a unit.

C. Constraints and Load Models

In the loading process, floating dock's slideway should always be aligned with the shore's slideway and at the same level, and its stern to be fixed with the pier. In view of the above, we must restrict the Y-direction and the Z-direction of the bow transom plate and the stern transom plate, and the bow transom plate is restrained in the X direction. In addition, considering that only half of the model is built, symmetrical constraint on the mid-longitudinal section is required.

The loads mainly include:

- (1) Floating dock own weight;
- (2) The weight of the off-loading product acting on the float box deck;
- (3) The external water pressure on the bottom plate of the

pontoon;

(4) Water pressure when the pontoon deck is submerged in water;

(5) Ballast water pressure of ballast tank.

IV. EXPERIMENTAL RESULTS AND ANALYSIS

According to the off-loading conditions of floating dock, the entire off-loading process is divided into 41 steps, each step on the dock 5 meters, this experiment select the water interval of 20m of the state to calculate: on the dock 0m, on the dock 20m, on the dock 40m, On the dock 60m, on the dock 80m, on the dock 100m, on the dock 120m, on the dock 140m, on the dock 160m, on the dock 180m, on the dock 205m. Taking 0m, 100m and 205m for example, the corresponding simulation results are given.

A. Conditions Analysis of Loading 0m

Ballast water distribution of ballast tank of loading 0m shown in Table I.

TABLE I. DOCKING 0M LOADING PLAN

Ballast tank	High level/m	Weight/t	Ballast tank	High Level/m	Weight/t
NO.1 left	2.255	1125	NO.1 left middle	2.933	917
NO.2 left	2.933	1463	NO.2 left middle	2.933	917
NO.3 left	2.933	1390	NO.3 left middle	2.933	917
NO.4 left	2.933	1446	NO.4 left middle	2.933	906
NO.5 left	2.933	1463	NO.5 left middle	2.933	917
NO.6 left	2.251	1123	NO.6 left middle	2.933	917

The calculation results are shown in Figure 5-6. Figure 5 shows the equivalent stress map of the whole dock, and Figure 6 shows the Z deformation map of the whole dock.

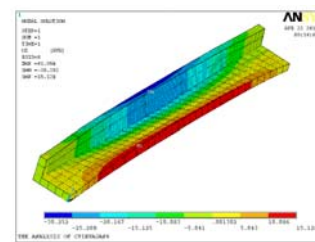


FIGURE V. THE EQUIVALENT STRESS

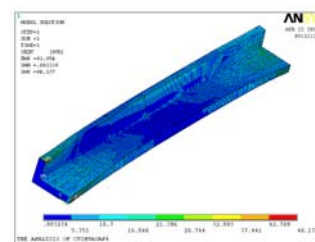


FIGURE VI. THE Z DEFORMATION

Docking product 0m, the ballast water is basically an average distribution, docking product weight is 0t, the impact on the structure strength of the dock is mainly from the buoyancy and the weight of the dock. It can be seen from Fig. 5 that the maximum equivalent stress is 48.137Mpa and the approximate coordinates point of the maximum stress is (0,19800,16000). Since the position is at the stern transom plate and there is no external load, the extreme value is mainly caused by constraints, so you can ignore the impact of the extreme point of stress. After removing the area affected by the its two ends' restraint, the stress in the floating dock is basically in the smaller state within 20 MPa, which is more in line with the actual situation.

It can be seen from Fig. 6 that the maximum Z-direction deformation is -30.252mm. The approximate coordinate point of the maximum deformation is (113600, 23300, 1370), which is located at the outer dock wall behind the midship. The general situation of the Z direction deformation of the floating dock: in the longitudinal direction, due to the constraints of both ends of the dock body, under the action of gravity and buoyancy, bend down from the tow ends of the boat to the midship. In the horizontal direction, the weight load of the dock wall part is larger and the buoyancy force is smaller, the resultant force is down, the pontoon part is subjected to a larger buoyancy and a smaller weight load, and its resultant force is upward, so that the dock wall part is bent downward and the pontoon part is upwardly arched.

B. Conditions Analysis of Loading 100m

Ballast water distribution of ballast tank of loading 100m shown in Table II.

TABLE II. DOCKING 100M LOADING PLAN

Ballast tank	High level/m	Weight/t	Ballast tank	High Level/m	Weight/t
NO.1left	1.933	965	NO.1 left middle	2.664	826
NO.2 left	2.313	1154	NO.2 left middle	2.933	917
NO.3 left	2.933	1390	NO.3 left middle	2.933	917
NO.4 left	4.217	2060	NO.4 left middle	2.933	906
NO.5 left	4.221	2106	NO.5 left middle	2.933	917
NO.6 left	3.885	1939	NO.6 left middle	3.587	1121

The calculation results are shown in Figure 7-8. Figure 7 shows the equivalent stress map of the whole dock. Figure 8 shows the z-deformation map of the whole dock.

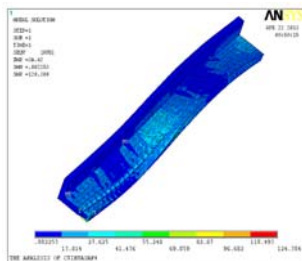


FIGURE VII. THE EQUIVALENT STRESS

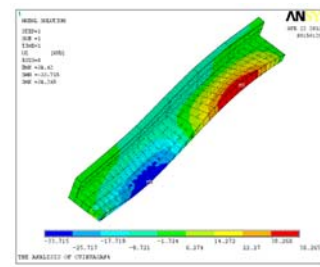


FIGURE VIII. THE Z DEFORMATION

Docking product 100m, the ballast water adjust: NO.2 left drainage, and NO.6 left water injection, the total weight of docking products is 6213t. It can be seen from Fig. 7 that the maximum equivalent stress is 124.304Mpa. The maximum stress value is at the coordinate point (68160, 19800, 438): that is the intersection point of No. 96 rib at watertight transverse bulkhead, pontoon deck, dock wall. The whole dock stress value mainly in the 55Mpa range.

It can be seen from Figure 8 that the S-shaped of Z-direction deformation is very obvious. The maximum Z-direction deformation in the front of the floating dock's midship was 38.265 mm, and the approximate coordinate point (150520, 0, 2250) at the position where the maximum deformation was located was at the mid-longitudinal section at 68 ribs behind the midship. The maximum Z-direction deformation is -33.715mm on the downward direction of the floating dock's postmedian, and the approximate maximum position of the maximum deformation is behind the halfway length of the mid-longitudinal section of the docking.

C. Conditions Analysis of Loading 205m

Ballast water distribution of ballast tank of loading 205m shown in Table III.

The calculation results are shown in Figure 9-10. Figure 9 shows the equivalent strain map of the whole dock. Figure 10 shows the z-deformation map of the whole dock.

TABLE III. DOCKING 205M LOADING PLAN

Ballast tank	High level/m	Weight/t	Ballast tank	High level/m	Weight/t
NO.1left	2.410	1203	NO.1 left middle	2.664	826
NO.2 left	2.255	1125	NO.2 left middle	2.933	917
NO.3 left	2.925	1396	NO.3 left middle	2.891	904
NO.4 left	2.785	1375	NO.4 left middle	2.871	888
NO.5 left	2.709	1352	NO.5 left middle	2.434	761
NO.6 left	2.843	1419	NO.6 left middle	3.587	1121

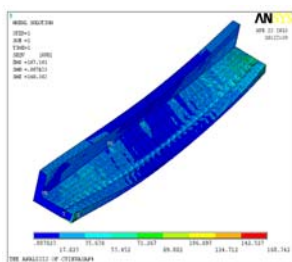


FIGURE IX. THE EQUIVALENT STRESS

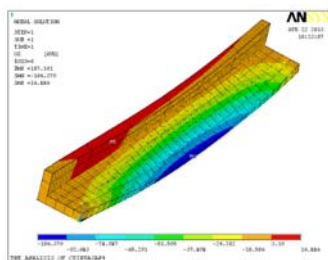


FIGURE X. THE Z-DEFORMATION

Docking product 100m, the ballast water adjust: NO.4 left drainage, NO.6 left drainage, the total weight of docking products is 14173t. It can be seen from Fig. 9 that the maximum equivalent stress is 160.342Mpa and the maximum stress coordinate point is (68160, 19800, 4328), that is the intersection point of No. 96 rib at watertight transverse bulkhead, pontoon deck, dock wall. Floating dock stress is mainly in the 71Mpa range.

It can be seen from Figure 10 that the maximum Z-direction deformation is -106.379mm on the downward direction of the floating dock's postmedian, and the approximate position of the maximum deformation's coordinate point is (-110160,0,0).

D. Analysis Conclusions and Recommendations of Docking

(1) Through the calculation of eleven typical situations during the loading process, the deformation of the floating dock structure in the Z direction during the loading process was obtained. In the initial stage of product docking, the weight load of the dock product at the stern of the floating dock and the ballast water injected at the bow of the floating dock together make the Z-direction deformation of the floating dock appear longitudinally in the shape of arching from the two ends to the midship. In the horizontal direction, relatively speaking, due to the large buoyancy of the part of the dock wall and the large buoyancy force and small weight of the pontoon, the floating dock is in a shape of arching from the side to the longitudinal section. The whole Z-direction deformation of the floating dock is as follows: The whole deformation direction of the floating dock is as follows: the maximum deformation point is taken as the center of the floating dock, and the elliptical shape with the long axis of X axis is gradually reduced outward; as the length and weight of the docked product increase, The downward deformation of the stern of the floating dock gradually increases, the deformation of the corresponding bow decreases, and the shape of the floating dock is S-shaped. When the length of the docking product exceeds half of the

length of the floating dock hull, the deformation of the stern of the floating dock begins to be larger than that of the bow and the S-shape will gradually disappear, presenting the elliptical shape with the largest deformation point as the center and the X-axis as the long axis outward gradually increased from the negative maximum value. The maximum relative vertical deformation of the floating dock hull at each loading condition is -140.624, and the approximate location is at the junction of the 164th rib position of the mid-longitudinal section and the bottom floor of the pontoon, relative to the length of the dock is 0.0684%. The deformation of the floating dock is not too much big. However, due to the weight load of docking product on the upper dock, the floating deck below the slideway causes a large local deformation there. Therefore, it is advisable to reinforce the structure of the potoon that is subjected to the weight of the docking product.

(2) Through the calculation, the equivalent stress distribution of the floating dock under various loading conditions is obtained: at the initial stage of the docking product, due to the weight load of the docking product on the floating dock, the stress extreme appears at the intersection of the stern transom plate and the pontoon deck which loads the weight of the docking product. As the length and weight of the docking product increased, the stress extremes alternated at the intersections of the watertight transverse bulkhead at No.162 rib position, the pontoon deck and the inner wall of the dock wall, and the intersections of the watertight transverse bulkhead at No.96 rib position, the pontoon deck and the inner wall of the dock wall. The cause of stress extreme value: on the one hand where the intersection of the three plates, the resistance of the external force is larger, so that stress concentration point is easy to occur there, on the other hand the load is greater there. Where the length of the docking product is less than half the length of the floating dock, the mid-longitudinal bulkhead presents a region of higher stress near the length of the floating dock. With the increase of the length of docking product, the stress extremes of various loading conditions also showed an upward trend. The maximum equivalent stress in the whole loading process occurred at 205 m on the upper dock and the equivalent stress value was 160.342 MPa, located at the intersection of the watertight transverse bulkhead at No.96 rib position, the pontoon deck, the inner wall of the dock wall. It is recommended that AH32 or DH32 high-strength steel with a yield point of 315MPa should be used for such places at the design and construction of floating docks. At the same time, reasonable construction techniques should be used to avoid stress concentration.

(3) In summary, the total longitudinal strength of the floating dock body is satisfied, and the entire off-loading process is also safe and reliable.

V. CONCLUSION

In this paper, simulation experiment of the force of floating dock during off-loading based on ANSYS is carried out, taking a 22000t lift floating dock as an example, an all-dock simulation model was established by using ANSYS. Constraints and loads were applied to 11 typical load conditions of the off-loading process followed by simulation of the structural stress and deformation of the floating dock during

off-loading. The results show that: 1) The ultimate stress points in the docking process of the product are mainly at the intersection corner of the pontoon deck, the watertight transverse bulkhead, the inner wall of the dock wall, and the junction of the pontoon deck, stern transom plate, slideway, as the length of docking product increases, the ultimate stress value also gradually increases; 2) During the off-loading process, the Z-direction deformation of the floating dock successively undergoes three typical deformations: convex deformation, S-shaped deformation and concave deformation. In addition, because of the weight load of the launching vessel, the local deformation of the pontoon deck below the slideway is larger.

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