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ANALYSIS ON THE STRUCTURE TRANSFORMATION OF LANDING CRAFT

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ABSTRACT

With the development of naval ship, many loading crafts with small displacement are replaced. However, it can be reused in coastline and multi-islands areas by improving carry capacity because the retired ships have excellent performance and unique construction. Therefore, how to transform a loading ship with small displacement into a civil carrier with large capacity was discussed. A three-dimensional ship model was established in MAXSURF, and the idealistic transformed model could be obtained by static stability calculation. Then, the model was verified by IMO regulation in stability at large angles of inclination. The total longitudinal flexural strength of the craft in sagging and hogging condition and the local strength were calculated and tested in detailed. The results show that to increase the principal dimensions of the landing craft can improve the carrying capacity successfully, which is an economic, convenient and feasible approach and can provide reference for the transformation and reutilization of the retired ships.

Keywords: Landing craft, Strength analysis, Finite element method, MAXSURF, ANSYS.

1. INTRODUCTION

Nowadays many retired ships have been discarded, which is so wasteful. Because the aim of the landing craft building is for the war, the safety margin of strength and stability is more than the civil ship's, so it can be transformed into a larger capacity civil carrier. In the paper, the research is to increase the length of paralleled middle body of the landing craft can improve the carrying capacity successfully, which is economic, convenient and feasible approach.

In the paper, the hydrostatic stability was calculated, and the idealistic transformed model could be obtained. Then, the model was studied in stability and strength. According to the equal displacement approach, the stability was calculated by using MAXSURF. By means of ANSYS, the total longitudinal flexural strength and the local strength were calculated. Finally, the model was verified to meet the civil ship construction and inspection criterion.

2 SHIP STABILITY CALCULATION

2.1 The hydrostatic stability calculation

In this paper, taken a landing craft for example, the hydrostatic stability[1] is calculated in different length and different state which include the full load offshore, full load inshore, no-load offshore, and no-load inshore. Then the total trim was obtained. According to the principle of avoiding trim by the bow at full load, the idealistic lengthened value could be calculated. After a three-dimensional ship model was established, the stability at large angles of inclination was calculated and tested by IMO regulation.

Table 1. The principal dimensions of the landing craft

principal dimension	values
Overall length(L)	27.6 m
Length on waterline(L_{WL})	26.9 m
Molded breadth(B)	5.4 m
Molded depth(D)	2.7 m
Calculated draft(T)	1.29 m
Displacement(Δ)	153.4 t

Because the landing craft has unique construction, the original ship model is established according to the principal dimensions. The model is imported to HYDROMAX, and the no-load weigh and the center of gravity were calculated. Then the compartment of the ship model is plotted out. The compartment definition is given as follows:

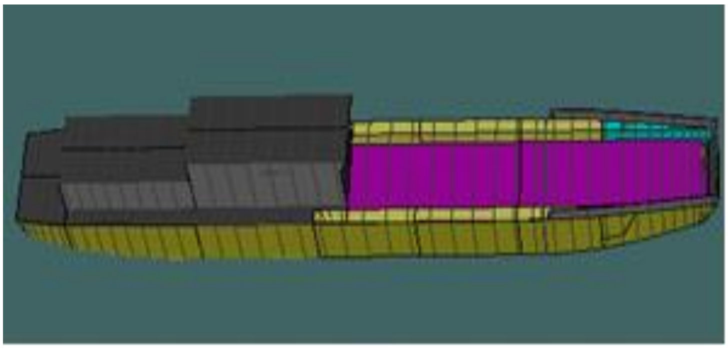

Figure 1. Compartment Definition

The stability is calculated at different length, and it is from 27.6m to 28.6m, 29.6m, 30.6m, 31.6m, 32.6m, and 33.6m, which refer to various hydrostatics parameters, such as weight, center of gravity, center of buoyancy, position of transverse metacenter and position of longitudinal metacenter. By means of the “Specified Condition” program, the other hydrostatics parameters can be gotten, which takes into account the longitudinal trim.

According to the results at different length, the ship longitudinal trim trend can be obtained. The trend of longitudinal trim at two conditions, full load offshore and full load inshore. From the calculation, it can be concluded as: with the paralleled middle body lengthening, the trend of the longitudinal trim values is decline. When the lengthened paralleled body is up to 6m, the values of longitudinal trim are 0.005m and 0.152m in full load offshore and full load inshore conditions. If the trim by the bow happens, there will be some troubles, such as decreasing in steerageway, taking wave on the deck easily and rudder racing, etc. For avoiding the trim by the bow, the lengthen value was chosen as 6m.

2.2 The intact stability calculation

According to the equal displacement in curve of intact stability theory, the stability at large angles of inclination at different length is calculated in HYDROMAX. For checking the stability of ship in various load state, the arm of stability is needed to calculate in different displacement. The equal volume waterines [2] method has two types. The first one is suitable to sea ships that have higher freeboard and the straight curve of broadsides. The second one is suitable to river boats that have lower freeboard and broadsides extraversion. In the paper, the first one is adopted. When ship float, centre of buoyancy is B_0 When an angle of athwart ship inclination is φ , the ship float on the waterline $W_\varphi L_\varphi$, at which the centre of buoyancy is B_φ, the coordinates are y_{B_φ} and Z_{B_φ}, the arm of stability is shown as follows:

$$l = \overline{GZ} = \overline{B_0R} - \overline{B_0E} = y_{B_\varphi}\cos\varphi + (Z_{B_\varphi} - \overline{KB_0})\sin\phi - \overline{B_0G}\sin\varphi \tag{1}$$

Obviously, if the location of $B_\varphi(y_{B_\varphi}, z_{B_\varphi})$ can be gotten, the arm of stability that is l can be calculated. Proceeding on incline an infinitely small angle d_φ , the inclining waterline is $W_{\varphi+d\varphi}L_{\varphi+d\varphi}$, which volume is equal to the one under $W_\varphi L_\varphi$.

$$dy_{d\varphi} = \overline{B_\varphi B_{\varphi+d\varphi}}\cos\varphi \tag{2}$$

$$dz_{d\varphi} = \overline{B_\varphi B_{\varphi+d\varphi}}\sin\varphi \tag{3}$$

$$\overline{B_\varphi B_{\varphi+d\varphi}} = B_\varphi B_{\varphi+d\varphi} \tag{4}$$

Because the equation is shown as follows:

$$B_\varphi B_{\varphi+d\varphi} = \overline{B_\varphi M_\varphi} d\varphi \tag{5}$$

So $\overline{B_\varphi M_\varphi}$ can be gotten, which is shown as follows:

$$\overline{B_\varphi M_\varphi} = I_\varphi / \nabla \tag{6}$$

I_φ is a moment inertia in vertical axis of the area under waterline($W_\varphi L_\varphi$) to the center of floatation (F_φ).

$$dy_{B_\varphi} = \overline{B_\varphi M_\varphi} d\varphi\cos\varphi \tag{7}$$

$$dz_{B_\varphi} = \overline{B_\varphi M_\varphi} d\varphi\sin\varphi \tag{8}$$

The state that an angle in athwartship inclination is Z_i similar to the overlap integral of countless infinitely small athwart ship inclination angles ($d\varphi$), which is shown as follows:

$$y_{B_\varphi} = \int_0^\phi \overline{B_\varphi M_\varphi}\cos\varphi d\varphi \tag{9}$$

$$z_{B_\varphi} = \overline{KB_0} + \int_0^\phi \overline{B_\varphi M_\varphi}\sin\varphi d\varphi \tag{10}$$

If the I_φ can be calculated and the $B_\varphi(y_{B_\varphi}, z_{B_\varphi})$ can be gotten by formula of (6) and (10), the arm of stability (l) can be calculated by formula (1). It is a key step to calculate the location of the equal volume under waterline. Actually, to solve the problem is adopted the repeated iteration method. Given $d\varphi$ and the initial waterline location on the midline, the program calculate the displacement that be compared with the given displacement, which process isn't stop until the difference between the calculated displacement and the given displacement less than the given error.

2.3 The inspection of the results

The HYDROMAX adopt the IMO A.749 (18) regulation. In the full load offshore condition, the freeboard is low and GZ is maximum. After the stability at large angles of inclination is calculated, the results at 33.6m length meet the IMO regulation. The calculation method in the other conditions, such as full load inshore, no-load offshore, no-load inshore, is similar to the above. All the results meet the IMO regulation.

3. CALCULATION OF THE OVERALL STRENGTH AND LOCAL STRENGTH

3.1 The total strength calculation

In the paper, the total longitudinal flexural strength [3] of the craft at 33.6m in sagging and hogging condition is calculated by HYDROMAX. Considering safety, the wave height is set to be 4m. The calculation of the sagging bending moment and the hogging bending moment in the wave is shown as follows:

$$M_{hog} = M_{SW} + 0.19C_W L^2 (B_{wl2} + K_2 B_{tn}) C_B = 1.53\times10^9 N\cdot MM \tag{11}$$

$$M_{sag} = M_{SW} + 0.14C_W L^2 (B_{wl2} + K_3 B_{tn})(C_B + 0.7) = -1.98\times10^9 N\cdot MM \tag{12}$$

M_{SW} — Still water bending moment; B_{tn} — The width of the cross-structure (the width of the tunnel).
Coefficients K_2, K_3 can be gotten from the following formulas:

$$K_2 = 1 - \frac{z - 0.5T}{0.5T + 2C_W} \tag{13}$$

Z — The height from the base line to the wet deck. The results are used in the calculation in local strength.

3.2 The local strength calculation

In calculation of the local strength, the finite element ship model is built in ANSYS [4]. The total length of the model is 12m, which is divided into NO1, NO2, and NO3. The SHELL63 [5] are used to mesh deck, bulkhead, broadsides, ribs, brackets, etc. The BEAM4 [6] are used to mesh girder, stiffening beams, deck's transverse beams, longitudinal beams, etc. The ship model is divided into 516105 units [7].

The boundary conditions are two aspects. First, two sides are rigid fixing, in the left side restrict Ty,Tz, Rx,Rz and in the right side restrict Ty,Tz,Rx,Rz. Second, all the nodes in the central longitudinal section are restricted the Ty,Rx and Rz.

Putting the appropriate loads on the ship model is very important to the successful calculation. The external loads consist of the wave load, the gravity load and the inertial load. The wave load, which includes the hydrostatic pressure and the hydrodynamic pressure, is put on the shell element. The draft at full load offshore is 1.291m, in which the water pressure is equal to one in the baseline. The pressure in the other station can be calculated by interpolation method. The gravity load include the cargo load, such as 40t tank weight (the width of caterpillar is 623mm and the area interfaced with inner bottom is 4050mm). The inertial load has gotten, $M_{hog} = 1.53\times10^9 N\cdot M$ and $M_{sag} = -1.98\times10^9 N\cdot M$.

The analysis includes the following 4 load states:

Load state 1: Hogging, NO.2 full load, NO.1 and NO.3 no load; Load state 2: Sagging, NO.2 full load, NO.1 and NO.3 no load; Load state 3: Hogging, NO.2 no load, NO.1 and NO.3 full load; Load state 4: Sagging, NO.2 no load, NO.1 and NO.3 full load. The deformation map in the fourth state is as follows:

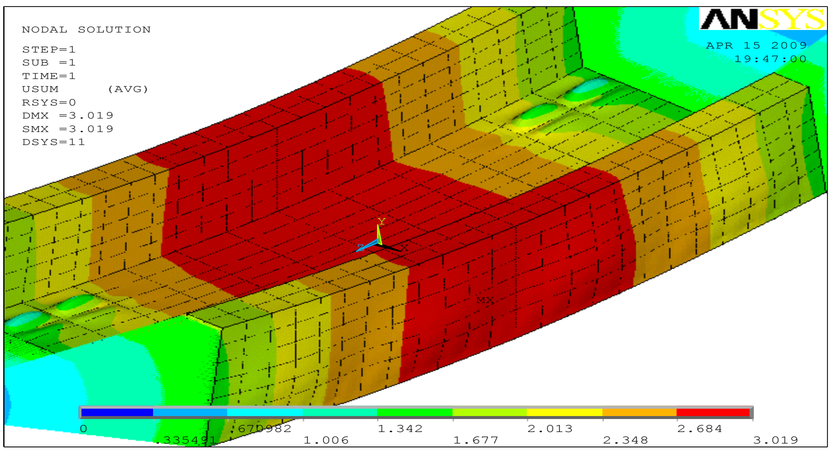

Figure 2. The deformation map in the fourth state

4. CONCLUSIONS

Firstly, in this paper, it is discussed how to transform the landing craft, especially in increasing the principal dimensions.Secondly, after calculating the hydrostatic stability and intact stability, it can be obtained that increasing the principal dimension of the landing craft meet the stability criterion. Thirdly, after calculating the total longitudinal flexural strength and the local strength, it is verified that the transformed landing craft meet the corresponding regulations. Fourthly, the lengthened landing craft is tested to meet the civil ship construction and inspection criterion. Another conclusion, the retired naval ship can improve the carrying capacity to 28% through increasing the principle dimension.

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