

# Fatigue analysis of assembled marine floating platform for special purposes under complex water environments

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**Abstract.** In this paper, the fatigue lives of a new type of assembled marine floating platform for special purposes were studied. Firstly, by using ANSYS AQWA software, the hydrodynamic model of the platform was established. Secondly, the structural stresses under alternating change loads were calculated under complex water environments, such as wind, wave, current and ice. The minimum fatigue lives were obtained under different working conditions. The analysis results showed that the fatigue life of the platform structure can meet the requirements

## 1. Introduction

The work studied a new type of combined marine floating platform for special purposes (Figures 1, and 2). The platform consists of standard floating body modules. The upper part adopts steel structure, laid with board, while the upper uses buoys to provide buoyancy. According to the requirements of use, they can be combined into required sizes.

In order to ensure the platform with a certain degree of seakeeping, it is necessary to establish a finite element model for the new floating platform. What's more, we should study its hydrodynamic characteristics and mooring schemes under load impact of wind, wave, flow and ice<sup>[1-4]</sup>.

Fatigue life under the condition of alternation of wave load is analysed by ANSYS Mechanical analysing platform in this article. Main designing load is constant load of wind, wave and ice and alternated wave load. 0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330 degrees of wave phases are chose to simulate a whole wave period, in order to calculate wave loads in different phases and exert them to platform respectively, analyse stress and fatigue life of platform after that.

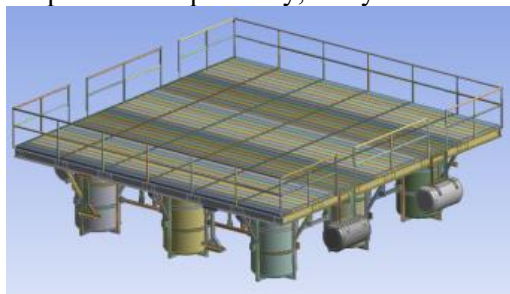


Figure 1. Axonometric drawing 1



Figure 2. Axonometric drawing 2

## 2. Overview of environmental loads

Wind loads were calculated based on CCS standard, with wind speed of 51.5m/s in self-existence state.

Flow loads were analysed by unidirectional fluid-solid coupling between Fluent and Mechanical, with the flow load calculated by Fluent transferring to the wet surface of Mechanical structure. The velocity of water flow used 0.85m/s, like the condition of once-in-a-decade in the South China Sea.

Ice loads were calculated in accordance with the contents of volume 2 of the CCS *<Rules for Classification of Sea-going Steel Ships in 2015>*, with consideration of a uniform load of 0.5 kN/m<sup>2</sup> on the deck, so as to account for snow, ice or other environmental loads.

Designed wave of floating platform is determined according to CCS *<Guidelines for Structural Continuous Assessment and Emergency Response Service of Mobile Offshore Units>*.

### 3. Combination of working condition

The problem of platform about structural strength, under the condition of combined effect of wind, wave, current and ice, especially the combination of designed wave of different directions, periods and heights and other loads, should be settled, in order to simulate the most dangerous situation. Ice load is forced on exterior surface of platform as pressure, while load of wind, wave and current need to be settled directions. Table 1 shows the working condition in the combination of wind, wave and current.

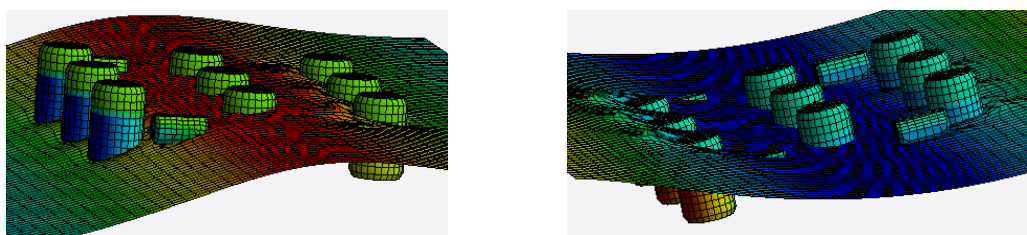
**Table 1.** Combination of Working Condition of Wind, Wave and Current

Working condition	Wave			Direction of current	Direction of wind	Comment of dangerous condition
	Period (s)	Height of wave (m)	Direction			
1	2.774	1.693	90	90	90	Separat-ing force between buoyancy tank
2	2.857	1.795	45	45	45	Longitu-dinal shear
3	2.332	1.197	45	45	45	Longitu-dinal torque
4	1.961	0.846	0	0	0	Vertical bending moment

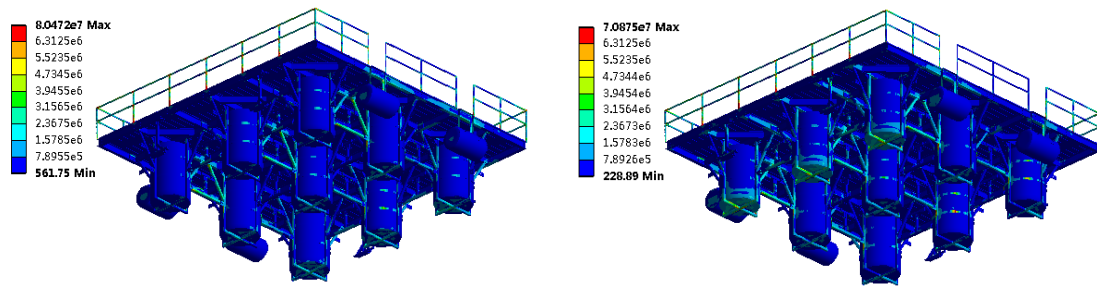
### 4. Analysis of structural strength of different wave phases

Since the fatigue analysis is based on the structural stress calculation, it is necessary to calculate the structural stress under alternating change loads before calculation of fatigue life. According to the CCS *<Rules for Classification of Sea-going Steel Ships>*, the fatigue analysis should focus on wave, among all of the cyclic loading. As a result, as for the above four load cases, changes in structural stress field caused by the phase changes of the wave are the focus in the following analysis. Specifically, when the loads of wind, flow and ice are taken into account, different phase wave loads will be calculated, respectively. Afterwards, the system simulates the alternation of the structural stress in the whole wave cycle, according to different phase waves.

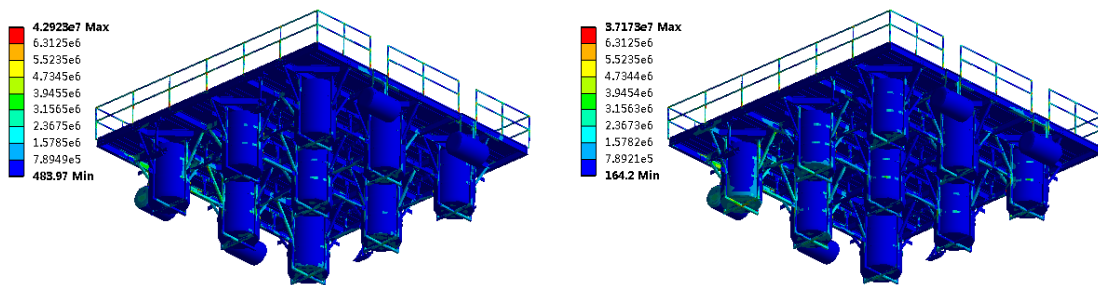
Different phase wave loads can be extracted in AQWA (Figure 3), so as to transfer the statistics to ANSYS Mechanical for strength analysis<sup>[5]</sup>.



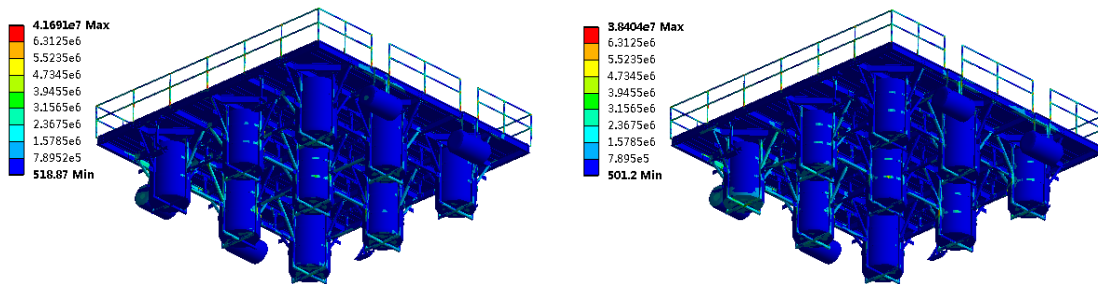
**Figure 3.** Alternation of Different Phases of Waves



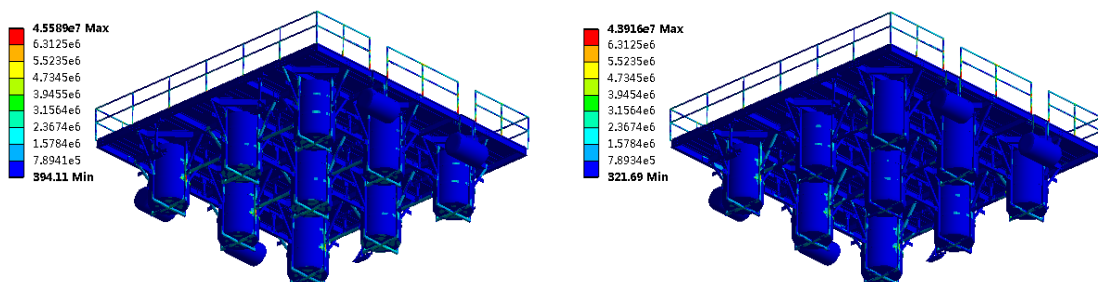
**Figure 4.** Structural Stress Contour Plot of Alternation of Different Phases of Waves (Working Condition One)



**Figure 5.** Structural Stress Contour Plot of Alternation of Different Phases of Waves (Working Condition Two)



**Figure 6.** Structural Stress Contour Plot of Alternation of Different Phases of Waves (Working Condition Three)



**Figure 7.** Structural Stress Contour Plot of Alternation of Different Phases of Waves (Working Condition Four)

From Figure 4 to Figure 7, it is shown that stress distribution of platform is different under different conditions of wave load.

## 5. Fatigue analysis

The existing strength analysis has shown that there is no danger of yield or buckling failures in the platform structure. However, owing to the cyclical effect of the waves, the stress analysis of the platform also changes periodically. As a result, the fatigue life analysis of the platform should be conducted to determine if the service life meets the requirements.

Base on the CCS <Rules for Classification of Sea-going Steel Ships>, the fatigue life of the structure should not be designed less than the life of the platform, as well as not less than 20 years.

The work utilized the fatigue analysis function of ANSYS Mechanical, so as to conduct fatigue analysis on the stress calculation results.

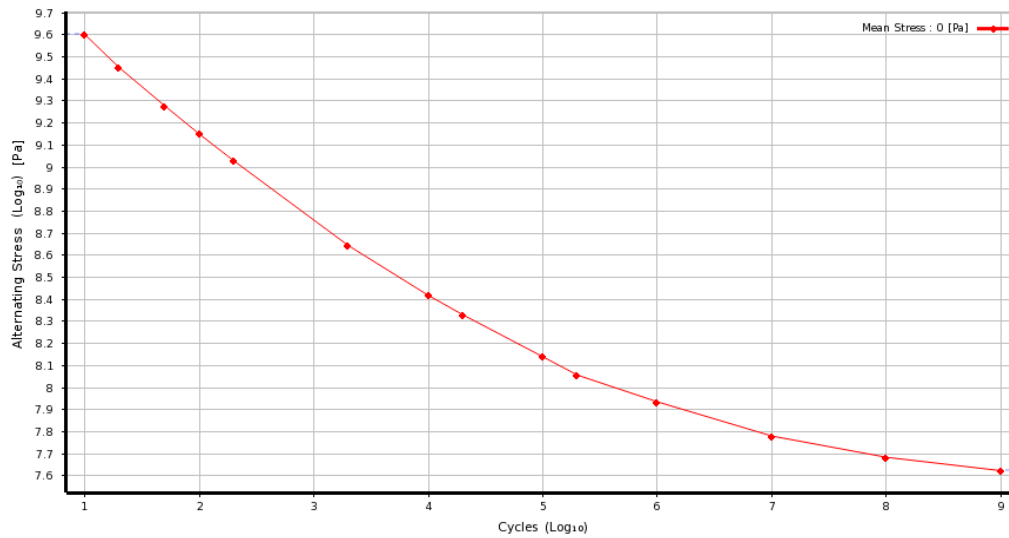
### 5.1. Fatigue material parameters

Data of S-N curve is given on steel material. Stress amplitude and corresponding working life is shown in Table 2. The calculation above is under the condition of without considering fatigue life of board wood.

**Table 2.** Data of S-N Curve of Steel Material

Cycle times	Stress Amplitude (kPa)
10	3999000
20	2827000
50	1896000
100	1413000
200	1069000
2000	441000
10000	262000
20000	214000
100000	138000
200000	114000
1000000	86200
10000000	60300
100000000	48300
1000000000	42000

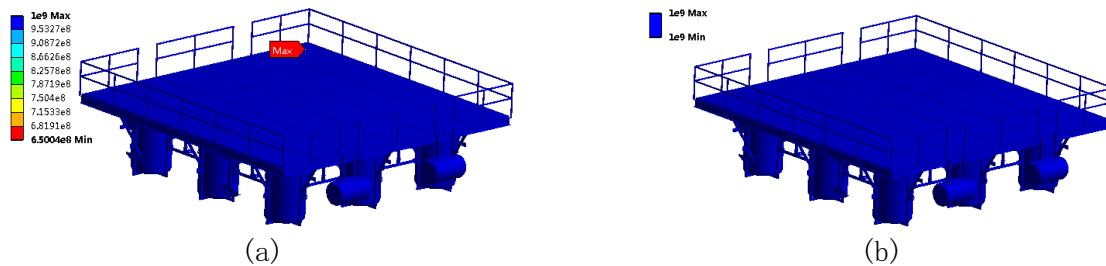
Logarithmic form is adopted in horizontal and vertical coordinates of S-N curve of steel material. Calculated S-N curve is shown in Figure 8.



**Figure 8.** S-N Curve of Steel Material

### 5.2. Analysis of fatigue life

Because of the low stress level, stress fatigue life is selected as the type of fatigue analysis. Figure 9 (a) shows the fatigue life cloud picture of the output in mode one. As for the fatigue analysis of other three modes, they have same fatigue life cloud picture of the output. As shown in Figure 9 (b), the result is infinite life, which means the number of fatigue cycles is  $1e9$  times greater than the maximum fatigue life inherited in the material.



**Figure 9.** Contour Plot of Fatigue Life

Working condition fatigue life and its unit converted into years are shown in Table 3. The minimum fatigue life is about 78.75 years, larger than 20 years, which is required in CCS <Rules for Classification of Sea-going Steel Ships>.

**Table 3.** Fatigue Life under Each Condition

Working condition	Fatigue life (Cycle times)	Wave period (s)	Fatigue life (year)
1	$\geq 6.5e8$	2.774	$\geq 78.75$
2	$\geq 1e9$	2.857	$\geq 124.78$
3	$\geq 1e9$	2.332	$\geq 101.85$
4	$\geq 1e9$	1.961	$\geq 85.65$

## 6. Conclusion

The work carried out the structural strength analysis and fatigue analysis on the platform under the alternation of wave, obtaining the minimum fatigue life under different working conditions. From the fatigue analysis results, the minimum fatigue life of the platform is about 78.75 years, larger than the minimum fatigue life required in the *CCS Rules for Classification of Sea-going Steel Ships* for 20 years. Therefore, the fatigue life of the platform structure can meet the requirements.

## References

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