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Dynamic Calculation of Waves in Ocean Engineering Based on Damping Waves

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Abstract: With the development of numerical computer simulation technology, the application of numerical wave troughs to simulate the motion and deformation of waves and their interaction with the ground has become an important development direction of computational fluid dynamics. The purpose of this paper is to study the dynamic calculation of waves in marine engineering based on damping waves. In this paper, the study of the irregular wave reflection of numerical wave flow is based on the VOF method. Taking the turbulent motion-Reynolds equation as the governing equation, the negative work technique is used in the near-wall region. The active receiver is placed on the left side of the waveform generator. The absorbing effects of different attenuation coefficient sponge layers and the effects of different attenuation coefficient power ratios on water reflection in the tank were compared. Good cleaning power. It can be seen from the spatial distribution of the wave surface height in the water tank along the water tank that the selected attenuation coefficient of the sponge layer can reduce the traveling wave in this region by one to two times the length and width. The spectra under different reservoir conditions are in good agreement with the target. The numerical calculation results show that the wave sponge cold resistance technology adopted in this paper can avoid the reflection at the output boundary. Combined with the active wave generation technology, the irregular wave based on the VOF method does not show the numerical groove of the wave.

1. Introduction

As a common phenomenon of ocean movement, there are always waves on the surface of the ocean. When we travel on the beach, sometimes it is bright and sometimes cloudy, so people think that the waves are the sea that is a symbol of nature rope. There is no doubt that waves have a great impact on human activity near beaches and shorelines. For example, waves play a very important role in coastal erosion, the destruction of offshore and marine engineering structures, the formation of coastal currents, ship navigation and even drag. And the sum of their owners has cultivated and developed many classical theoretical systems, such as wave and random wave patterns [1-2].

In the research of wave dynamic calculation based on damping wave in ocean engineering , many scholars have studied it and achieved good results, for example : Na J introduced the concept of damping wave technology in sponge layer for the first time, and adjusted the artificial damping area sponge by adjusting layer size to generate reflected waves. Attenuate according to the law, so as to achieve the purpose of receiving wave energy [3]. Based on the VOF method, Gong C studied the wave breaking process and the shock process, and established the numerical boundary conditions and well structure of the water contact separation by the VOF method [4].

In this paper, the unsteady wave response of nonlinear dynamic motion is studied based on the VOF method. Active absorption is set at the left end of the spectrum. This paper compares the wave reflection results for different attenuated sponge layers, the effect of different power levels on water reflection, and the optimal reflection and the optimal cardinality. Has excellent absorbing effect. component power. The numerical calculation results show that the wet-layer wave-elimination technology adopted in this paper can avoid the reflection of the output boundary, and combined with the active wave technology, the irregular wave digital slit based on the VOF method will not appear.

2. Research on Wave Dynamic Calculation in Marine Engineering Based on Damping Wave

2.1. Numerical Stability--Convergence Conditions

In order to make the whole calculation process stable, the cell size and time need to be limited. The choice of scale must satisfy the condition that all independent variables exhibit the expected change. The time step can be obtained from a local linear stability analysis of the equation.

(1) The first basic restriction is: Courant condition

$$\delta_t < \min\left(\frac{\delta x}{u_{i+\frac{1}{2},j}}, \frac{\delta y}{v_{i,j+\frac{1}{2}}} \right) \tag{1}$$

That is, the fluid δt is not allowed to cross the adjacent cells within the step length. In order to ensure a certain degree of safety, it is δt selected to be about a quarter of the right-hand term of the above formula [5-6].

(2) The second limiting condition is the diffusion stability condition

$$\left(v + \frac{v_i}{\sigma_k} \right)\delta_t < \frac{1}{2}\left(\frac{1}{\delta x_i^2} + \frac{1}{\delta y_j^2} \right)^{-1} \tag{2}$$

That is, the diffusion motion of the fluid in one time step cannot cross the adjacent cells [7-8].

2.2. Damping Absorption Oof Waves

This design idea originates from the wave-absorbing bank of the wave tank. A damping term is added to the boundary of the free surface to absorb the waves propagating outward, that is, the sponge layer is arranged from a certain distance from the outlet boundary to absorb the wave energy, so that the wave energy transmitted to the outlet boundary can be absorbed. is zero, so that the infinitely far outer domain can be simulated in a finite region. The sponge layer wave elimination method is not sensitive to the incoming wave frequency (or wavelength), and can effectively eliminate incoming waves of various frequencies (or wavelengths). Absorbing waves with a sponge layer has not yet given a satisfactory explanation in theory, but has received good results in practical applications. At present, it has become a common method for dealing with boundary conditions [9-10].

In this paper, a certain length of sponge layer is set at the outflow boundary to absorb the traveling wave, and five different forms of damping attenuation coefficients are used in the sponge layer.

2.3. Fluid-Structure Interaction

Fluid-Structure Interaction Dynamics includes knowledge of fluid mechanics, solid mechanics and dynamics, specializing in the interaction between solids and fluids. The solid foundation will adjust or move under the influence of the water load, and the change or movement of the solid will affect the flow field, changing the magnitude and distribution of the water load [11-12].

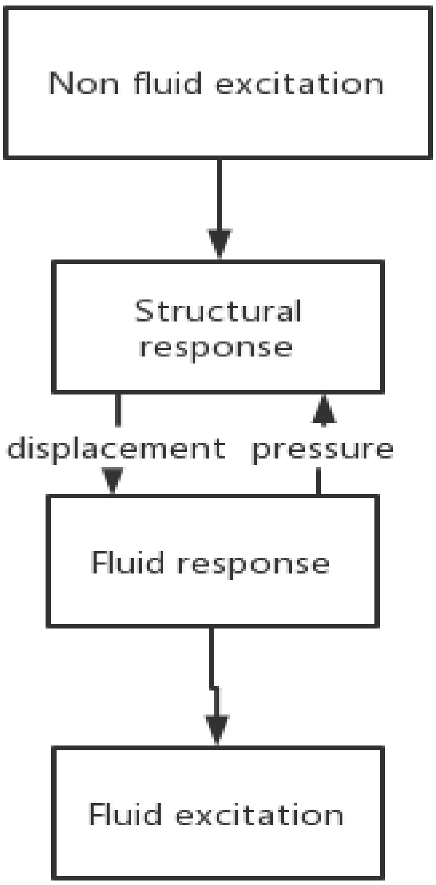

Figure 1. Flow-solid coupling system

As shown in Fig. 1, in the connected interface, the flow pressure will affect the motion of the solid, which in turn affects the characteristic distribution of the flow field. Fluid pressure and solid motion are unknown at the connection interface and can only be obtained after the entire hydraulic system is determined. After the integration scheme is defined, the fluid flow integration problem becomes a dynamic problem under a given surface pressure and a hydrodynamic problem for a single fluid under given boundary conditions [13-14].

3. Research and Design Experiment of Wave Dynamic Calculation in Marine Engineering Based on Damping Wave

3.1. Numerical Methods in this Paper

Considering the applicability to practical application problems with complex geometric shapes (such as wave deformation on complex terrain and flow problems around curved structures), the model in this paper will use unstructured mesh elements. In two dimensions, consider two basic elements, the triangle and the convex quadrilateral. The finite volume method is more and more widely used in computational fluid dynamics because of its good conservation properties and its suitability for both structural and non-structural properties. Like the interFoam solver, the model in this paper will also adopt the basic paradigm of "unstructured mesh + finite volume method". Two high-precision formats suitable for unstructured grids, namely VPM and THINC/QQ, will be used to solve the momentum equation and capture the free surface, respectively; the velocity and pressure solution process within a time step will be carried out according to the projection method [15- 16].

3.2. Experimental Design

In this paper, two different data simulation methods are studied for numerical waveforms, and the differences and different application scenarios of the two methods are analyzed. Secondly, the convergence of the model in this paper is analyzed.

4. Experimental Analysis of Wave Dynamic Calculation in Marine Engineering Based on Damping Wave Absorption

4.1. Comparative Analysis of the Two Methods

In this paper, the numerical waveform research is carried out for two different methods, and the differences and application scenarios of the two schemes are analyzed and analyzed mainly through the wavelengths of two different numerical simulations. The data are shown in Table 1.

Table 1. Price ison of wavelength analysis for two different methods

	100	110	120	130
Stokes A third-order wave	4	6	4	6
Linear wave theory solutions	-6	4.5	-6	4.5

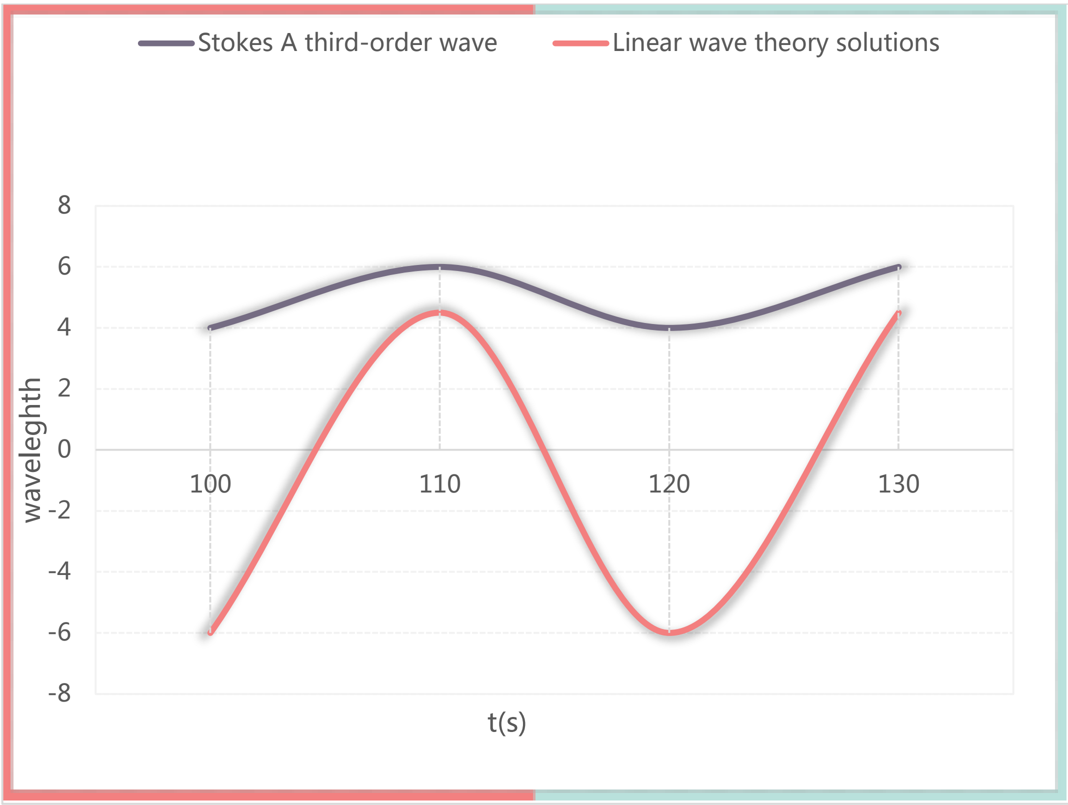

Figure 2. Comparison of the two numerical waveforms

Figure 2 shows the comparison of the two numerical waveforms of the Stokes third-order wave and the linear wave. It can be seen that the Stokes third-order wave has a sharper peak and a flatter trough, which verifies that the Stokes wave has a sharper peak as described in the Stokes wave theory. The trough is relatively flat and close to the shape of a cycloid [17-18] .

At the same time, by simulating waves by using the moving boundary wave-making method based on the pusher plate and the water-quality point velocity wave-making method, the comparison of the two schemes can draw the following conclusions:

(1) Both the moving boundary wave-making method and the water quality point velocity wave-making method based on the pusher plate can obtain numerical waveforms that are consistent with the theoretical waveforms, but the moving boundary wave-making method is near the pusher plate, due to the disturbance of the pusher plate. effect, the numerical wave height will be greater than the theoretical wave height.

(2) The time step of the moving boundary wave making method is set to 0.05s, while the time step of the water quality point velocity wave making method is set to 0.01s, the time spent in the calculation of ten wave cycles is roughly the same, so the water quality point velocity wave making method takes approximately the same amount of time. The computational efficiency of the method is relatively high.

4.2. Time Convergence Test

After the initial verification of the wave-making and wave-elimination modules, convergence tests will be carried out on the time step and grid size to study the sensitivity of the solver to time and space discretization. It is worth noting that to show the accuracy of the wave phase, both the time and space sequences of the wave fronts are given below. Although the working area of the water tank has a length close to 20 times the wavelength, considering the practicality of engineering applications, this paper will examine the wavefront time series around 10 times the wavelength. The experimental data are shown in Table 2.

Table 2. Normalized wave parameters at different time steps

	0.008s	0.004s	0.002s
T	1.000	1.000	1.000
λ	0.999	0.999	0.999
H	0.974	0.997	0.997

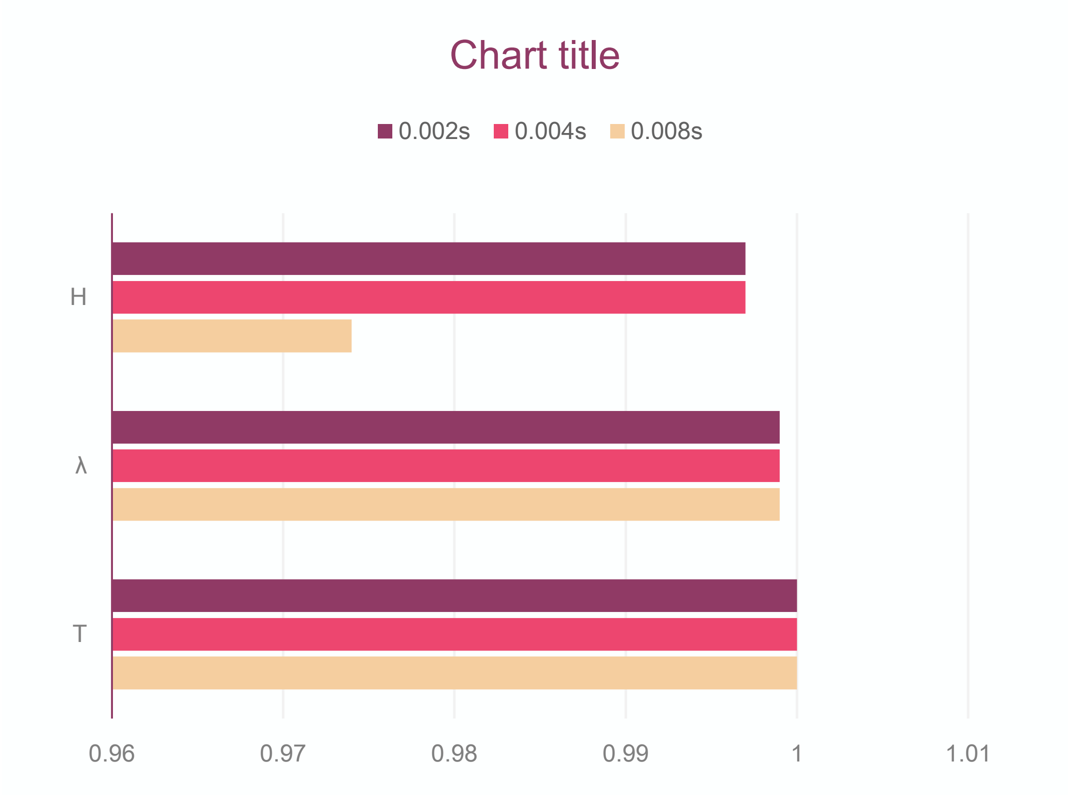

Figure 3. Standardized wave parameters of the model presented in this paper at different time steps

Figure 3 also shows the normalized wave height H/Ho, and the calculation method of the wave height H is consistent with the calculation method of the wave period T. It can be seen that when Δt=0.008s, the wave height error is the largest, and the interFoam result has a wave height attenuation of 26.8%, while the model in this paper only has a wave height attenuation of 2.6% .

5. Conclusion

In this paper , the damped wave absorption of an irregular wavenumber cell created by the VOF method is investigated . The equation is the force equation in the wave region. The active wave absorption boundary is defined at the left end of the numerical wave groove, and the straight wall boundary is defined at the right end and one end of the sponge layer to absorb waves. The space is arranged in front of the right wall. The main conclusions drawn are as follows: Five different damping attenuation calculation methods are used for the sponge layer. We chose the ripple effect. This coefficient is used as the attenuation coefficient of the sponge layer with irregular wave numbers based on the VOF method, and the optimal parameter value of the attenuation coefficient of the sponge layer under various wave element combinations is given. Let's summarize. The above, combined with the fundamental components of current waves, can be calculated by a combination of mixing and small-scale displacement in sea sponges. Mixed waves are easy to avoid. In order to avoid the reflection of the wave at the exit boundary, combined with the active wave processing technology, a numerical wave slot based on the irregular wave non-reflection method is adopted.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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