Experimental investigation on the hydrodynamic characteristics of knotless nylon netting panels in airy waves and visualization of the wave flow field

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INTRODUCTION

- As a critical component of fishing gear structures, flexible netting is subjected to complex environmental loads, including currents, waves, biological fouling, and interactions with entangled fish, each of which influences the hydrodynamic characteristics of the netting.
- In recent years, flexible netting has been widely used in applications such as fish cages and trash-blocking nettings at nuclear power plants, but the intense action of waves has brought numerous potential risks.
- As noted by the previous work, there is still no consensus on whether inertia forces can be neglected in wave forces, and the reasonable values for drag and inertia coefficients have not been unified. Additionally, most previous studies have focused on the hydrodynamic characteristics of nettings under wave cases, with few studies investigating the impact of nettings on the surrounding wave field and the interaction between nettings and water particles in waves.

MATERIALS AND METHOD

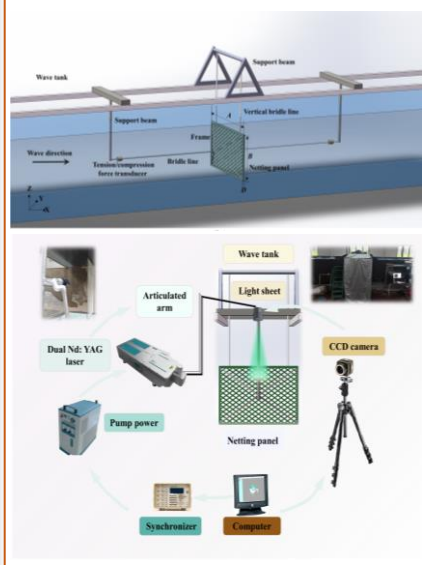

Fig. 1. Laboratory setup

The whole experiment was bifurcated into two segments. The initial phase encompassed the determination of hydrodynamic characteristics for four netting panels of diverse specifications, subjected to varying wave cases. The subsequent phase was dedicated to conducting tests for the meticulous analysis of the flow field distribution pertaining to different wave cases. All the laboratory experiments were carried out in the wave tank of the Rudong test base at the Fisheries Engineering Institute of the Chinese Academy of Fishery Science. The tank was 65 m long, 1 m wide, and 1 m deep, and it had an equilibrium water depth equal to 0.7 m during the experiment.

RESULTS AND DISCUSSION

Hydrodynamic force on the netting panel in waves

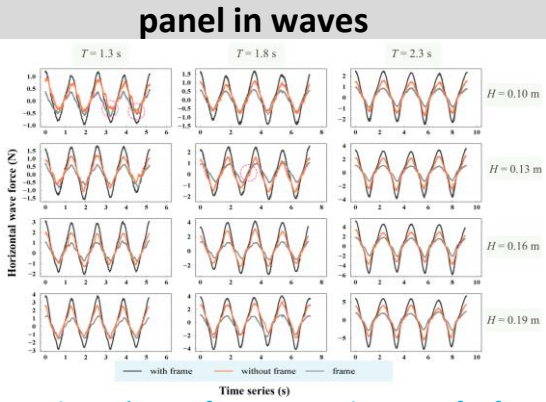

Fig.2. Horizontal wave force on Netting No. 1 for four wave periods during stable states under different wave cases

Component of Horizontal wave force

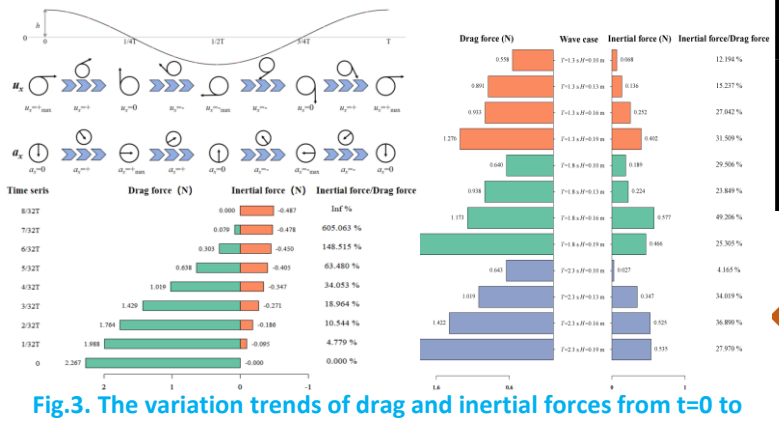

Fig.3. The variation trends of drag and inertial forces from t=0 to 1/4T and at 1/8 T among 12 wave cases

Hydrodynamic coefficients

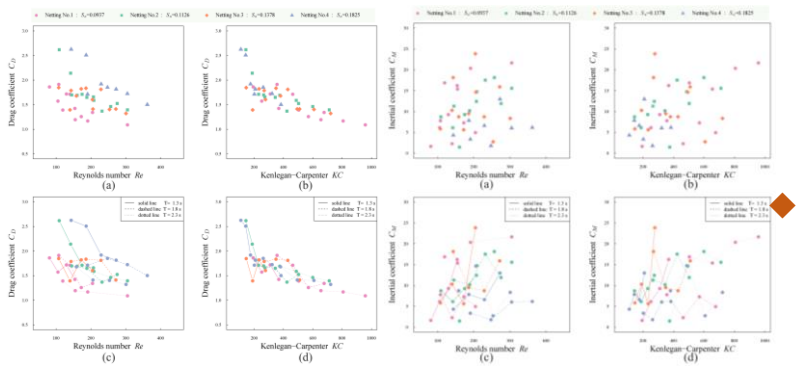

Fig.4. Drag and inertial coefficients with Reynolds number, KC number and frequency parameter *β*

Velocity variation under diverse wave phases

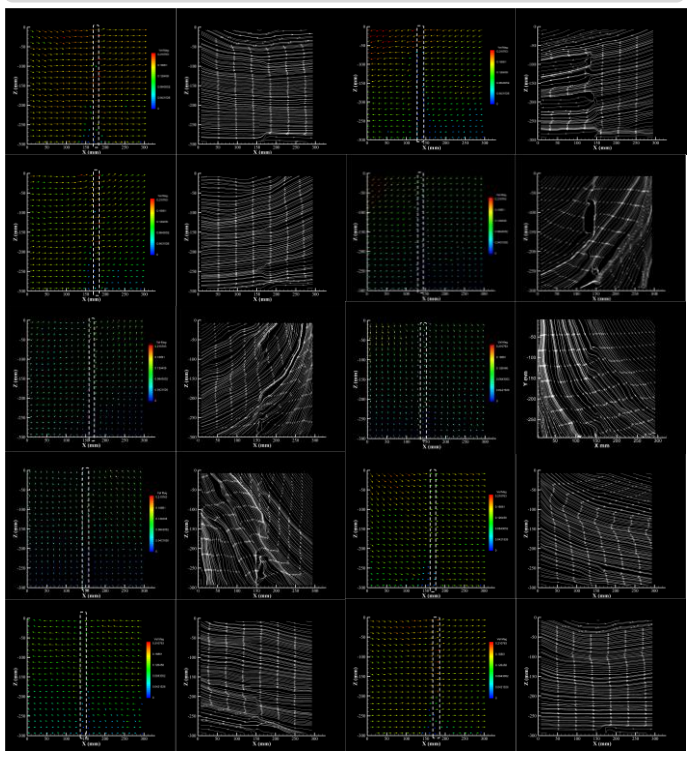

Fig.5. Velocity distribution and streamlines diagram of the flow field within one wave period (from peak to peak)

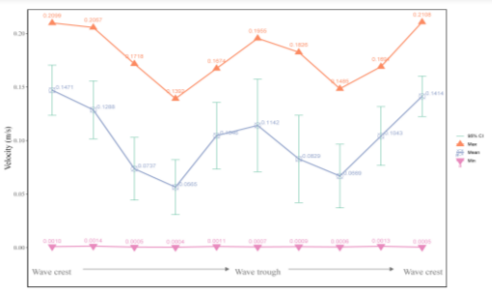

Fig.6. Variation in flow field velocity over one cycle (from peak to peak) at T = 1.8 s and H = 0.10 m

Velocity variation under diverse wave cases

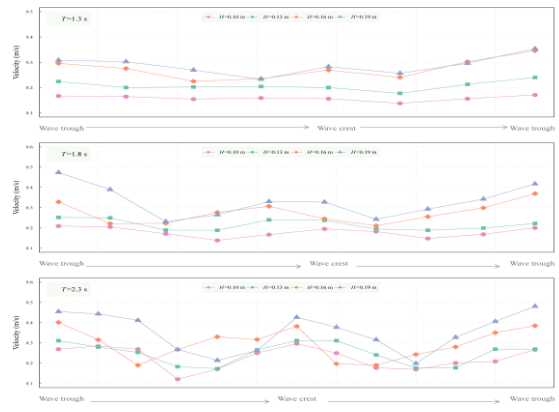

Fig.7. Trend of maximum water particle velocity around the netting panel for various wave cases

- Wave period, wave height, and netting solidity ratio were all positively correlated with the horizontal wave force on the netting. In the exploration of wave forces, inertial force cannot be neglected, especially at high Re or KC numbers.
- The drag coefficients of the four netting panels ranged from 1.169 to 2.625, while the inertial coefficients ranged from 1.642 to 23.845. The drag coefficient decreased with increasing Re and KC, with a sharp decline at low values followed by a slower decrease. The drag coefficients of the netting panels with different solidity ratios exhibited distinct ranges based on Re. There was no clear variation pattern of inertial force with Re and KC, nor a clear relationship with solidity ratio.
- The horizontal velocity variation of water particles over a wave cycle followed a pattern like that of wave forces, with maximum velocities at the crest and trough, and minimum velocities at the horizontal plane. In the measurement region for a given phase, the velocity decreased from top to bottom, with more pronounced velocity decay near the netting.
- As wave height or period increased, horizontal velocity values increased as well. Meanwhile, the amplitude of maximum velocity variation at different phases also increases with larger wave periods and heights.

CONCLUSION

The study provides a comprehensive understanding of the hydrodynamic characteristics of knotless nylon netting panels under various wave cases and conducts a preliminary exploration of the interaction between the netting and the surrounding flow field. While the research on hydrodynamics and hydrodynamic coefficients is well-established, some limitations remain in PIV experiments and image post-processing techniques. This aims to present a more accurate visualization of the flow field and a more comprehensive assessment of the interaction between the netting and water particles in waves, in hopes of providing references for optimizing netting design and operational practices, as well as selecting aquaculture environments.