Flow visualization around small roughness elements with a hydraulic scale-up model based on Re-Fr similarity law

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修士学位論文内容要旨
Abstract

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論文題目 Title	Flow visualization around small roughness elements with a hydraulic scale-up model based on Re-Fr similarity law (Re-Fr 則に基づく水理実験モデルによる微小粗度周辺の流況可視化実験)		

【Background and Objectives】

The movement of the ocean is very complicated and has dramatic effects on the nearby water environment, which can influence physical, biological, or socioeconomic processes related to living marine resources. Thus, it is necessary for us to find the potential rule of the movement of the ocean. However, due to the current technological limitations, the ocean movement studies on the real scale are hard to be conducted. Hydraulic model test provides a useful method for us to simulate the real water environment, which is constructed and operated at a reduced scale and offers an alternative for examining coastal phenomena. Meanwhile, hydraulic model combines with PIV (Particle image velocimetry) method, which is a whole field, nonintrusive, indirect velocity measurement technique that can obtain the velocity information with high accuracy and temporal and spatial resolution by transferring the velocity information of the flow to the velocity information of tracer particles based on algorithms.

The motivation of the experiments is to focus on the flow visualization around small roughness elements with hydraulic scale up model based on Re-Fr similarity law. Thus, the main objectives of this study include two aspects:

(1) Develop a new hydraulic model based on Re-Fr similarity law to simulate the real water environment.

(2) Verify the reliability of Re-Fr similarity law by comparing with Re similarity law and Froude similarity law.

【Methodology】

According to Re-Fr variable viscosity similarity scale-up model, the relationship between kinematic viscosity scale (λ_v) and length scale (λ_L) is $\lambda_v = \lambda_L^{3/2}$, which means if we know the length scale between the prototype and experimental model, we can completely simulate the water condition via changing the viscosity and length scale of the liquid. Therefore, I did the first experiment named 'falling sphere method to measure the viscosity of various CMC solution', which try to find the relationship between the concentration of CMC solution and the viscosity of CMC solution.

Then I did the second experiment named 'Application of Re-Fr similarity law to small roughness elements by using PIV method', to find the difference among the results of Reynolds similarity law and Froude similarity law.

【Results】

1. The results of the falling sphere method experiment are as follows:

$$(\nu_{cmc} - \nu_0) / \nu_0 = 4.5\times10^8 C_{cmc}^{2.4} \quad (0<C<000.5)$$

Where C_{cmc}: concentration of the CMC liquid, v_{cmc}: kinematic viscosity (cm^2/s) of the CMC liquid, v_0: kinematic viscosity (cm^2/s) of water.

2. The results of the second experiment show that at the same experimental condition, the results of the velocity profile have a big difference by following different similarity law.