VELOCITY CHARACTERISTICS IN WAKE OF A NON-SPHERE BODY AND IN PORE OF POROUS MEDIA COMPOSED OF NON-SPHERES

Yuji Yamamura, Osaka City University, kixctstexp@gmail.com
Takaaki Shigematsu, Osaka City University, shige@eng.osaka-cu.ac.jp
Sota Nakajo, Osaka City University, nakajo@eng.osaka-cu.ac.jp

BACKGROUND AND AIMS OF THIS STUDY

It is widely well-known that the porous body such as rubbles and blocks are effective to attenuate wave energy and to make calm sea area. However, we have not obtained enough knowledge of the mechanism of energy attenuation by them yet. In order to study their stability as a porous body and strength of a discrete block, it is essential to get knowledge of the fluid motion in the pore.

In general, a porous body composed of solid with different size and form. Therefore, form of the pore is complicated and inhomogeneous. In order to understand the velocity characteristics, PIV technique with refraction matching method was used to measure the velocity in the pore of porous body composed of spheres with a constant diameter (e.g. Nakajo et.al. 2008). They found that strong shear flow is generated in the continuous pores in the flow direction, which is a source of turbulence. Further, they pointed out that fluid force on the porous body and /or pressure drop during flow pass through the porous body do not obey the macroscopic models such as the Darcy and Forchheimer type under unsteady flow conditions.

In this study, first of all, velocity field in the wake of a sphere and an ellipsoid were measured by the PIV technique and flow characteristics of them were compared. Secondly experimental results were compared with calculated results by using the Immersed Boundary method. After validation of the numerical model, the flow field through the porous media composed of spheres and ellipsoids were calculated and flow characteristics in the pore of porous media was investigated.

EXPERIMENTAL SETUP AND NUMERICAL SCHEME

Experiment was carried out in an acrylic pipe flume with rectangular cross-section 0.2 m height, 0.1 m width and 1.0 m length (Figure 1). A sphere and a ellipsoid were made by 3D printer. The model of a sphere and a ellipsoid was fixed at the center of the pipe flume by polyethylene strings. By poring water into a circular column with a commutation layer by pump unidirectional laminar flow was generated. The PIV measurement was carried out under the Reynolds number $Re = V_0 D / \nu = 580 - 1160$ (V_0: velocity, D : characteristic diameter of a sphere or a ellipsoid, ν: kinematic eddy viscosity of fluid).

The immersed boundary method was applied to the calculation of the flow through a single sphere and a single ellipsoid. In addition, the flow through porous media composed of spheres and ellipsoids without turbulence model.

MAIN CONTENTS

The velocity characteristics around a single sphere and ellipsoid was investigated (Figure 2). In the presentation, velocity characteristics through the porous media composed of the ellipsoids may also be presented. More detail velocity characteristics was investigated based on the calculated results (Figure 3). In the calculation, velocity characteristics not only around a single sphere and ellipsoid but also through a porous body composed of the ellipsoids (Figure 4).

REFERENCES

Nakajo, Shigematsu, Tsujimoto, Takehara (2008) : An experimental study on turbulence induced by porous media, Proc. 31st international Conference on Coastal Engineering, pp. 4738-4750.

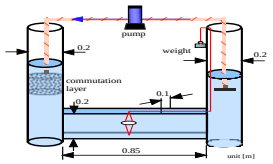
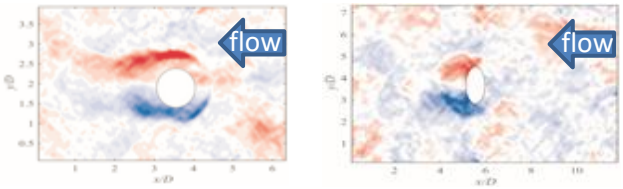


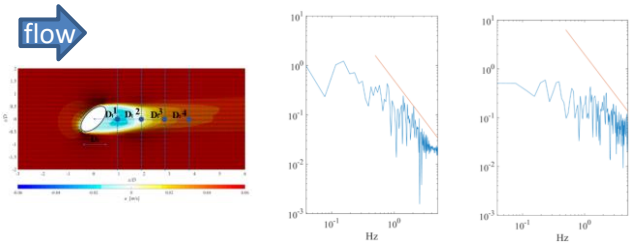
Figure 1: experimental apparatus

Photo 1:



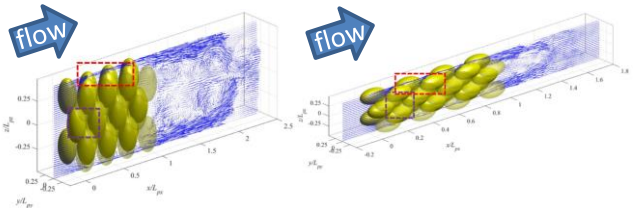
(a) sphere (Re=1150) (b) ellipsoid (Re=580)

Figure 2: experimental result (vorticities)



(a) velocity vectors (b) spectrum (P1) (c) spectrum(P4)

Figure 3: calculated results (ellipsoid: θ=45 deg.)



(a) θ=90 deg. (b) θ=0 deg.

Figure 4: calculated results