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Numerical evaluation of tsunami impact force acted on a bridge girder during tsunami by using a particle method

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INTRODUCTION

A couple of years have passed since the great east Japan earthquake, and new tsunami disaster prevention and mitigation methods are promoted actively toward the next millennium Tsunami. Numerical prediction of the fluid impact force acted on structures including bridges, private houses and buildings during tsunami is strongly desired for generating the new regulation of tsunami disaster prevention. In this study, the numerical evaluation of fluid forces acted on bridge girders is focused as a first step, and the Incompressible Smoothed Particle Hydrodynamics (ISPH) has been utilized to simulate complex flow phenomena around the bridge. There are mainly two originalities in our developing codes. One is the stabilization of the pressure value, and the other is the accurate boundary treatment. A stabilized ISPH[1] is adopted to improve the accuracy of the predicted pressure value without artificial pressure oscillation. In addition, new boundary treatment using a virtual marker and fixed boundary particle is developed to satisfy the slip and no-slip boundary condition for the velocity field and to satisfy the pressure Neumann condition at the same time. The accuracy and efficiencies of our proposed method are validated by comparison between a numerical solution and experimental results. After the validation, our proposed method is applied for real scale model.

VALIDATION FOR THE PROPOSED METHOD

The comparison between a numerical solution and experimental results has been introduced to validate the proposed scheme. This experiment was carried out by Nakao *et al* (2011) for the purpose of calculating the fluid impact force acting on the girder model. The analysis model and the shape of the girder model are shown in Fig.1. In this study, numerical result is compared in case that the water level is 30cm and the simulation is conducted on condition

that the particle distance $d_0 = 0.5$cm, time increment $\Delta t = 0.001$s and the total number of particles is about 8millions. Fig.2 shows the result of horizontal force in the box model by filtering to cut a component of more than 15 Hz as with the experiment. From the graph, the numerical result matches the experimental one at the practical level. In addition, we can get the result with much better accuracy than conventional method which uses fixed boundary particle and gives zero in velocity to the wall particle.

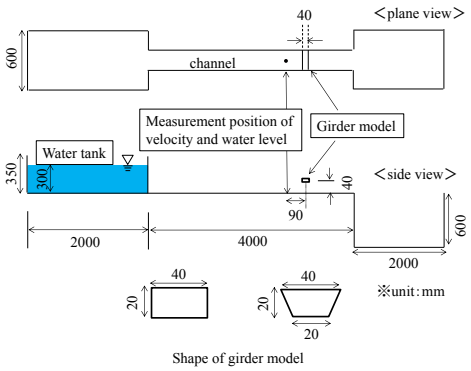

Fig.1 analysis model

APPLICATION FOR THE REAL SCALE MODEL

The fluid impact force acting on a real scale and shape girder model is estimated by applying the proposed method. The wave is modeled for a gentle stream and the depth in the model is 4m. The particle distance $d_0 = 12.5$cm and time increment $\Delta t = 0.001$s and the total number of particles is about 10 millions. Analyisis model and the result of pressure contour are shown in Fig.3 and Fig.4 respectively. According to the result, the pressure is higher in part of lower left of the girder and it can be shown that the lift force is important factor to prevent bridges from tsunami. During the past tsunami disasters, many bridge girders may be pushed away mainly because of the lift force acted on the girders.

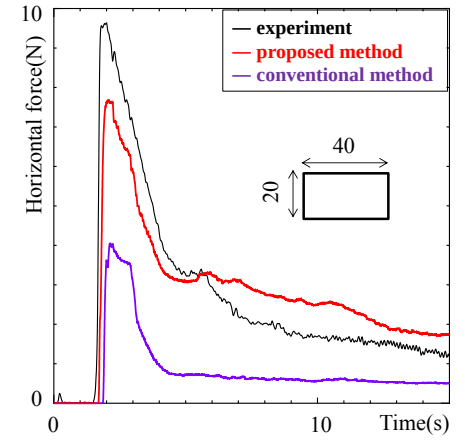

Fig.2 Fluid impact force

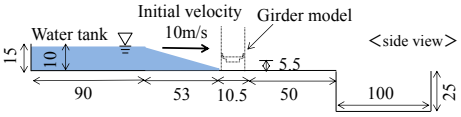

Fig.3 Real scale analysis model

CONCLUSION

The accuracy and efficiency of our proposed method are validated by comparison between a numerical solution and experimental results. From our numerical test, the proposed method can evaluate the fluid impact force acted on bridge girders with high accuracy.

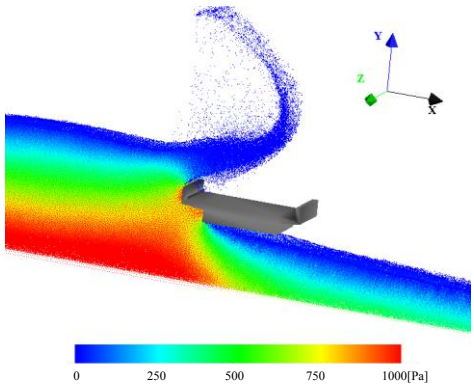

Fig.4 Pressure value

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