HORIZONTAL SOLITARY PRESSURE BY GIRDER POSITION PARAMETER BASED ON CADMAS

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1. INTRODUCTION

Based on our previous research of solitary experiments by girder position parameter, the horizontal pressure acting on a girder increases linearly with decreasing of girder height. In this paper, a numerical analysis software (CADMAS-SURF/3D) is used for the study of the mechanism of the pressure acting on the leading edge of girder changing with different girder positions.

2. HYDRAULIC EXPERIMENTS

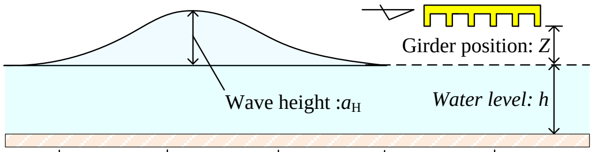
As illustrated in Fig. 1, a solitary wave is generated by the wave making plate, and then spreads to girder model. Wave gauge H6 measured the wave height at center of girder. Propeller velocity meter V1 measured the velocity beside of girder. Fig. 2 shows the experimental cases. All 3 experimental cases have the same water level (35cm) and the same solitary wave height (20cm). The experimental parameter is girder position Z, which starts from the water level to the bottom of girder model.

3. NUMERICAL CONDITIONS

A 3-dimensional open channel model and a 3-dimensional girder model are used. As shown in Fig. 1, the simulative field starts from H1, ends behind of girder model. Mesh number is 3,093,552 [=837 (length direction) × 42 (width direction) × 88 (height direction)]. Because this simulation starts from H1, the experimental result of H1 is input as wave height data. Since there is no velocity data in the hydraulic experiment at H1, the input velocity is computed based on the Boussinesq's theory.

4. NUMERICAL RESULTS OF Z/a_H=0 CASE

Firstly, the reproduction of wave height at girder model is checked. Figure 3 shows the wave height time history at H6 of Z/a_H=0 case, which was set beside of the girder. The time history shape of experimental data and calculated data are almost same. And then, V1 of Z/a_H =0 case checks the velocity reproduction and the time history is shown in Fig. 4. The calculated peak agrees well with hydraulic experimental peak. Next, P3 of Z/a_H =0 case is selected as an example to check the pressure reproduction and the time history is shown in Fig. 5. The experimental pressure peak is 1942 Pa. The calculated peak is



Case	Wave shape	Water level h [cm]	Wave height a_H [cm]	Girder position Z [cm]	Z/a_H
1	Solitory	35	20	0	0
2				8.3	0.4
3				16.6	0.8

Fig. 2 Experimental cases

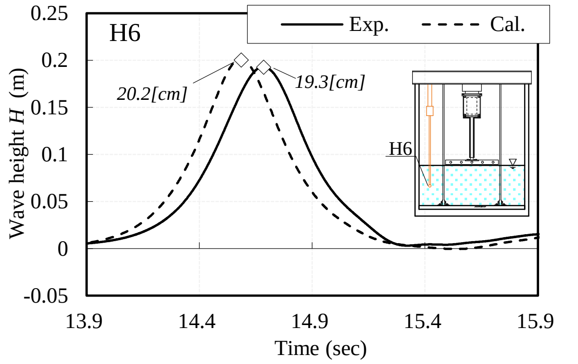


Fig. 3 Wave height time history of H6 (Z/a_H=0 case)

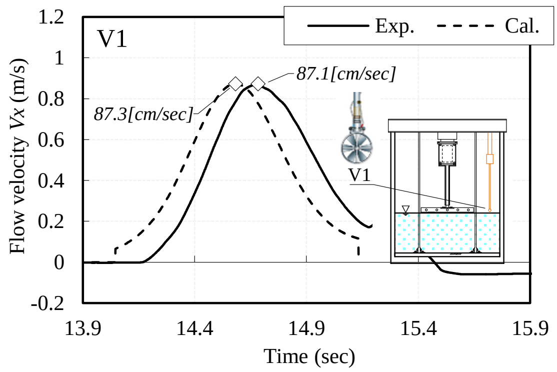


Fig. 4 Velocity time history of V1 (Z/a_H=0 case)

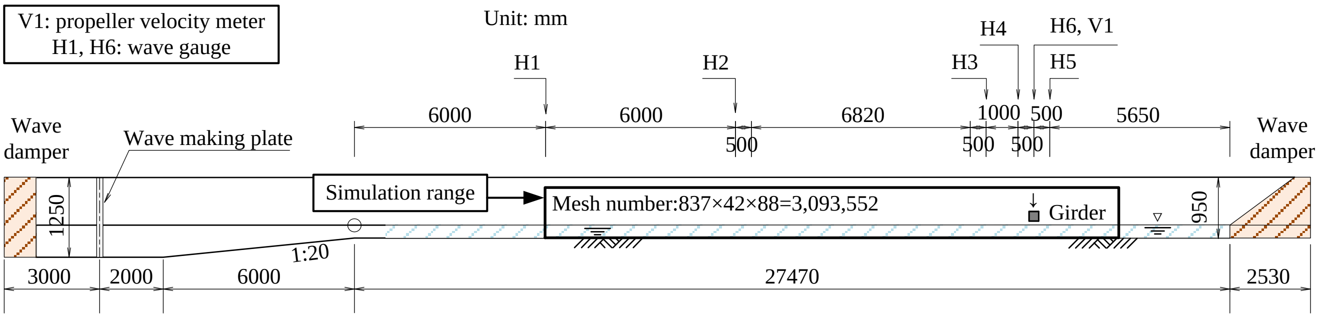


Fig. 1 Experimental open channel model

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1740 Pa, which can reproduce 90% of experimental peak.

In order to know the relationship between hydrostatic pressure and the pressure acting on girder, hydrostatic pressure time history of P3 is denoted by the chain line in Fig. 5. The hydrostatic pressure *P.static* is computed by Eq. (1).

$$P.static = \rho g a \qquad \text{Eq. (1)}$$

When wave closes to girder, *a* (the inundation height of P3) increases from zero to peak, which leads P.static also to go up. Thereupon, P.cal rises with P.static increasing. At 14.50 sec, P.cal reaches its peak. Figure 6 shows the pressure distribution front of girder at 14.50 sec. Calculated pressure is plotted by the circle solid line. The right triangle shows hydrostatic pressure. The pressure distribution shape of P.cal trends to be right triangle shape, which is similar with the pressure distribution shape of P.static. *Cell* [a] is located 35 mm below girder. Because velocity of *Cell* [a] is 0.76 m/s, hydrodynamic pressure is computed to be 289 Pa. Furthermore, the calculated pressure is 1472 Pa. 289 Pa pluses 1472 Pa equals 1761 Pa, which is 76% of the hydrostatic pressure value 1499 Pa. In addition, when wave spreads to H4, which locates 500mm front of girder, wave velocity is 0.9 m/s. When wave acts on girder, wave velocity changes from 0.9 m/s to be zero. Therefore, the hydrostatic pressure 405 Pa transforms into pressure on the leading edge of girder, which lead P3.cal to increase sharply to 1740 Pa.

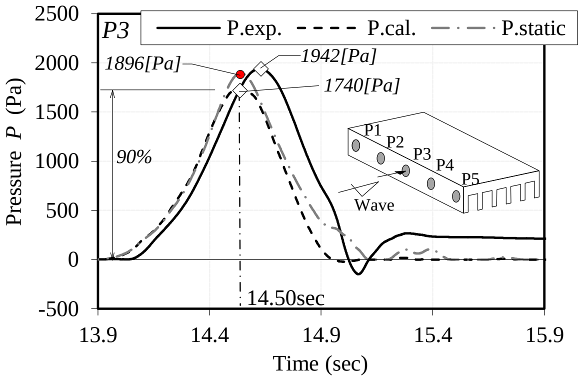

Fig. 5 Pressure time history of P3 (Z/a_H=0 case)

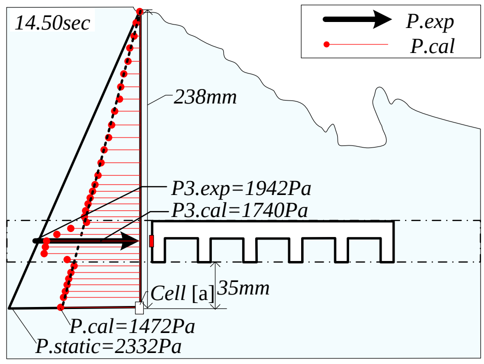

Fig. 6 Pressure distribution front of girder (Z/a_H=0 case)

5. NUMERICAL RESULTS OF Z/a_H=0.8 CASE

This section moves to the highest girder position case: Z/a_H=0.8 case. Same with Z/a_H=0 case, good agreement both of wave height and velocity can also be observed between experiment and simulation analysis. Figure 7 shows the pressure time history. The calculated pressure reaches its peak at 10.31 sec, which can reappear 88% of experimental peak.

Hydrostatic pressure of P3 time history is denoted by the chain line in Fig. 7. When wave closes to girder, *a* (the inundation height of P3) increases from zero to peak, which leads P.static also to go up. And then, P.cal rises with P.static increasing. At 10.31 sec, P.cal reaches its peak. Figure 8 shows the pressure distribution front of girder at 10.31 sec. The pressure distribution shape of P.cal also trends to be the same shape of pressure distribution P.static. *Cell* [b] is located 119 mm below girder. Because velocity of *Cell* [b] is 0.70 m/s, hydrodynamic pressure is computed to be 245 Pa. Furthermore, the calculated pressure is 1102 Pa. 245 Pa plus 1102 Pa equals 1347 Pa, which is 90% of the hydrostatic pressure value 1499 Pa. In addition, when wave spreads to H4, which locates 500mm front of girder, wave velocity is 1.1 m/s. When wave acts on girder, wave velocity changes from 1.1 m/s to be 0 m/s. Therefore, the hydrostatic pressure 605 Pa transforms into pressure on the leading edge of girder, which lead P3.cal to increase sharply to 877 Pa.

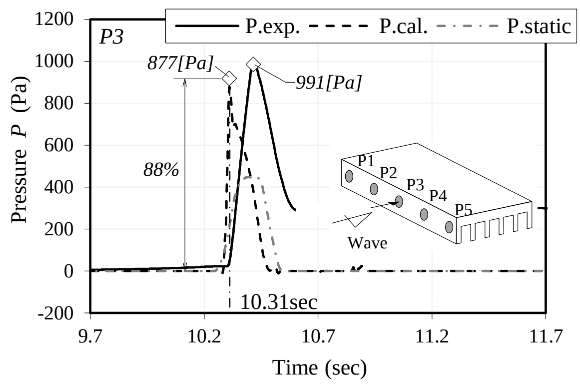

Fig. 7 Pressure time history of P3 (Z/a_H=0.8 case)

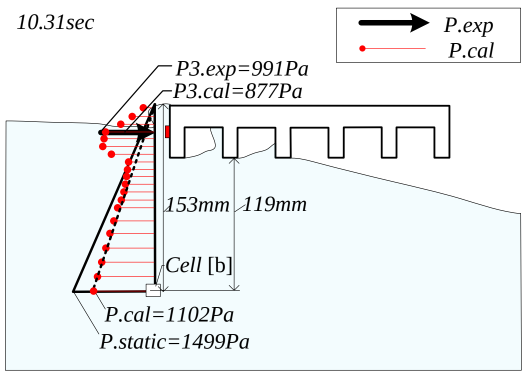

Fig. 8 Pressure distribution front of girder (Z/a_H=0.8 case)

6. CONCLUSIONS

(1)For reproduction of this simulation analysis, the calculated pressure can reproduce the experimental one well. For Z/a_H=0 and 0.8 case, the experimental pressure peak can reproduce 90% and 88% of experimental peak, respectively.

(2)For both of Z/a_H=0 and 0.8 case, pressure distribution shape of P.cal trends to be right triangle shape, which is similar with the pressure distribution shape of P.static. In addition, when wave acts on girder, dynamic pressure of P3 (405 Pa and 605 Pa) transforms into the pressure on the leading edge girder, which leads P3.cal to increase sharply.