Inundation Flow considering Overflow due to Water Level Rise by River Structures

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River structures such as bridge piers, bridge girders and spur dykes cause water level rise during flood situations, which is of great interests in engineering practices. The numerical study related to the flow around these river structures is necessary to consider the three-dimensional flow field. In particular, the three-dimensional model with the free water surface is needed to estimate the flow considering water level rise caused by the river structures. In the numerical simulations of the open channel flow, the free water surface is usually replaced by a rigid lid. This approach is suitable only if free surface is non-complex. For rapidly changing free surface, this approximation will introduce nonphysical errors. Therefore, in this study, the three-dimensional model with free water surface is developed and applied on a complex geometry.

There are many computing methods available to simulate the free water surface. One of the most successful methods has been the volume of fluid (VOF) method. This method's popularity is based on ease of implementation, accuracy and computational efficiency. The method is a powerful approach, but it is not known to have been implemented on the unstructured meshes. Also, instances of non-physical deformation of the interface shape have been reported. Therefore, a special consideration to simulate the free water surface is necessary. A high resolution scheme was employed to simulate the free water surface on the unstructured mesh.

The developed numerical model simulated the flow with the free water surface on the unstructured mesh. The model includes the standard $k - \varepsilon$ model for the turbulence closure and the volume of fluid (VOF) method for the computing of the free water surface. The laboratory experiments were conducted to investigate the variations of the river flow according to a kind of river structures under the same hydraulic conditions. The numerical results were compared with the results obtained from the experiments.
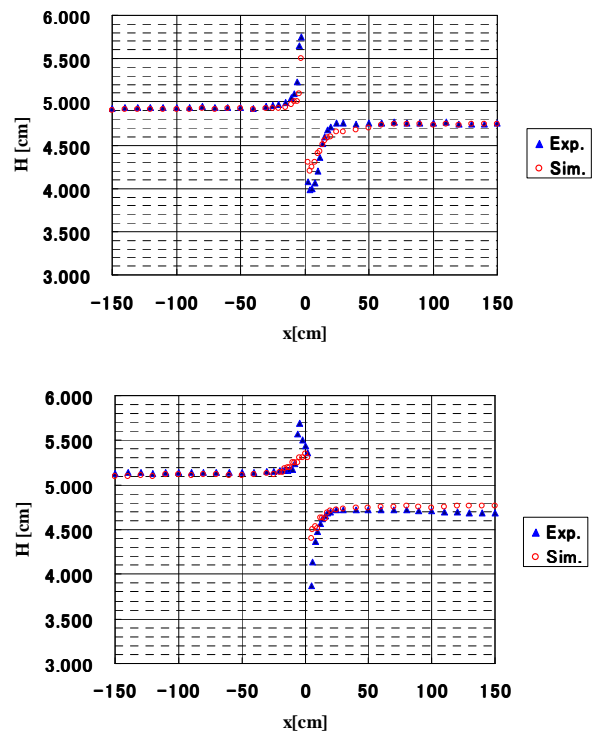

Fig.1 Results of experiment and simulation for water level

(top: bridge pier; bottom: bridge girder)

The prediction of the water level rise caused by the river structures is very important from the viewpoint of flood disaster. By comparing the experimental and computational results (Fig.1), it is shown that the numerical model can be used to simulate the flow considering overflow due to water level rise by the river structures although the results of the numerical model underestimates some water level rise.