Development of an unresolved fluid-beam coupling scheme based on Darcy-Brinkman equation

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The particle method is an effective numerical method for solving incompressible flows with free surfaces, such as tsunamis. Accurately predicting tsunami damage requires considering the collapse and advection of structures due to fluid forces. Therefore, it is necessary to treat the behavior of structures under tsunami as a fluid-structure interaction (FSI) problem. The conventional FSI analysis schemes need a larger dimension of structural members than the spatial resolution of the fluid domain (e.g. mesh size, particle spacing) to calculate fluid forces exerted on the structure, which is impossible for city-scale tsunami simulations in terms of computational cost. For this issue, an unresolved coupling scheme is effective. In this scheme, fluid forces can be calculated via a drag force model depending on the averaged fluid velocity and shape of the structure. Because the unresolved coupling scheme treats the shape of structure just as a parameter in the drag force model, there is no necessity to spatially resolve structural shape, and FSI analysis can be performed even when the spatial resolution of the fluid is coarser than the dimensions of structural members. Moreover, the effect of structures on fluid can be described by the Darcy-Brinkman equation which was originally proposed for seepage flow through porous media [1].

In this research, an unresolved coupling scheme based on the Darcy-Brinkman equation is developed for framed structure, and validity is verified. The ASI-Gauss technique [2] and ISPH method [3] are applied for structural and fluid analysis respectively. A dam-break analysis with a single cylinder was conducted to verify the drag forces calculated by the proposed method regarding ~~with~~ particle-to-cylinder diameter ratios. In addition, a dam-break analysis with a group of cylinders was conducted to verify the behavior of the cylinders against the flow.

References
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