A Coupling Method using Stabilized MINI Element of 2D Shallow Water Flow and 3D Gas-Liquid Two-Phase Flow

Junichi Matsumoto* and Kazuo Kashiyama†

* Research Center for Ubiquitous MEMS and Micro Engineering (UMEMSME)
National Institute of Advanced Industrial Science and Technology (AIST)
1-2-1 Namiki, Tsukuba, Ibaraki 305-8564, Japan
e-mail: matsumoto-junichi@aist.go.jp, web page: http://www.aist.go.jp

† Department of Civil and Environmental Engineering
Chuo University
1-13-27 Kasuga, Bunkyo, Tokyo 112-8521, Japan
e-mail: kaz@civil.chuo-u.ac.jp, web page: http://www.civil.chuo-u.ac.jp/lab/keisan/index.html

ABSTRACT

A coupling method based on an implicit mixed finite element method of two-dimensional shallow water flow with distribution of the wave and three-dimensional gas-liquid two-phase flow with LES (Large Eddy Simulation) is proposed in this paper. Boussinesq equations [1] are used to account for the distribution of the wave. Dynamic SGS model [2][3] is used by LES. A stabilized MINI element [4], bubble function element/linear element, with an implicit scheme in time is used to solve the Boussinesq equations [5] and the Navier-Stokes equations [6]. The stabilized MINI element means bubble function element stabilization method for triangular element and tetrahedral element. The estimation of gas-liquid interface for three-dimensional Navier-Stokes equations is employed an interface-capturing method based on a phase-field model (PFM) [7]. Cahn-Hilliard equation in PFM is applied to estimate the interface of gas and liquid. The stabilized MINI element is used to solve Cahn-Hilliard equation. Continuity condition satisfies for connecting the two-dimensional Boussinesq equations and three-dimensional Navier-Stokes equations [8]. A dam break problem is analyzed to verify presented coupling method as a computational example.

REFERENCES

[1] D. H. Peregrine, “Long Wave on a Beach”, *J. Fluid Mech.*, Vol. **27**(4), pp. 815-827, (1967).

[2] M. Germano, et al., “A dynamic subgrid-scale eddy viscosity model”, *Phys. Fluids*, Vol. **A3**(7), pp. 1760-pp.1765, (1991).

[3] D. K. Lilly, “A proposed modification of the Germano subgrid-scale closure method”, *Phys. Fluids*, Vol. **A4**(3), pp. 633-pp.635, (1992).

[4] J. Matsumoto, “A relationship between stabilized FEM and bubble function element stabilization method with orthogonal basis for incompressible flows”, *J. Appl. Mech. JSCE*, Vol. **8**, pp. 233-242, (2005).

[5] J. Matsumoto, T. Umetsu and M. Kawahara, “Stabilized bubble function method for shallow water long wave equation”, *Int. J. Comput. Fluid Dyn.*, Vol. **17**(4), pp. 319-325, (2003).

[6] J. Matsumoto, N. Takada and S. Matsumoto, “One hundred million DOF two-phase flow analysis of implicit mixed finite element method using phase-field model”, *Proceedings of Computational Engineering Conference JSCES*, Vol. **16**, (2011).

[7] J. Beaucount, et al., “Modeling Breakup and Relaxation of Newtonian Droplets Using the Advected Phase-Field Approach”, *Physical Review E*, Vol. **75**, pp. 021405(1-8), (2007).

[8] J. Matsumoto and K. Kashiyama, “A coupling method using FEM of 2D shallow water flow and 3D gas-liquid two-phase flow”. *APCOM & ISCM*, (2013).