A shape optimization of a body located in the flows of solitary wave propagation

Ichiro Uchiyama*, Mutsuto Kawahara† and Akira Maruoka††

* Ocean Consultant Japan Co., LTD
Dept. of Engineering
3-7-9 Shibaura, Minato-ku, Tokyo, 108-0023, Japan
E-mail: uchiyama@ocjpn.co.jp, Web page: http://www.ocjpn.co.jp

† Chuo University
Dept. of Civil and Environmental Engineering
1-13-27 Kasuga, Bunkyo-ku, Tokyo, 112-8551, Japan
E-mail: mutsuka0@gmail.com, Web page: http://www.chuo-u.ac.jp

†† National Institute of Technology, Hachinohe College
Dept. of Civil and Environmental Engineering
16-1 Uwanotai, Tamonoki, Hachinohe City,
Aomori Prefecture, 039-1192, Japan
E-mail: maru-z@hachinohe-ct.ac.jp, Web page: http://www. hachinohe-ct.ac.jp

ABSTRACT

A shape optimization of a body located in fluid flows is one of the main themes of the fluid dynamics. Many researchers have pursued to obtain the optimal shape in the case of air fluid. On the other hand, the studies concerning the shape optimization under the action of wave propagation are not many though it is useful in the field of coastal and marine engineering. The purpose of this study is to find out an optimal shape of a body under the action of solitary wave propagation. We use the governing equations of mass and momentum considering the slight compressibility. As to the governing equations, we applied the finite element method based on the generalized acoustic velocity method and stabilized techniques such as stream-upwind/Petrov-Garelkin (SUPG) method and arbitrary Lagrange-Eulerian (ALE) method. By using the stabilized techniques, the accuracy of the computation is dramatically improved. Furthermore, we have verified the applicability of our new computational fluid dynamics (CFD) models by comparing the computational results with the experimental results in the case of three dimensional solitary wave propagation. The optimal formulation is based on an optimal control theory which a performance function of fluid force should be minimized to satisfy the governing equations and the constraint condition. This problem could be solved by using adjoint equations. According to these procedures, an optimal shape under the action of solitary wave propagation could be obtained.

REFERENCES

[1] M. Kawahara, "Finite element method of incompressible, adiabatic, and compressible flows: From fundamental concepts to application", *Springer*, 2016.

[2] A. Maruoka, I. Uchiyama and M. Kawahara, "Finite element analysis of solitary wave propagation by acoustic velocity method", *Journal of computational mechanics*, 2016.

[3] H. Okumura, Y. Hikino and M. Kawahara, "A Shape Optimization method of a body located in adiabatic flows", *International journal of computational fluid dynamics*, 2013.

[4] T. E. Tezduyar, "Stabilized finite element formulations for incompressible flow computations", *Advances in Applied Mechanics,* Vol.28, 1991.