

# COMPARISON OF NUMERICAL WAVE TANKS WITH VARIOUS TURBULENCE MODELS IN APPLICATION TO LONG WAVE MOTION AND ITS INTERACTION WITH A VERTICAL WALL

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## INTRODUCTION

In this study, performances of interFoam solver of OpenFOAM and CADMAS-SURF computational tools with several turbulence modelling approaches on the numerical modelling of long wave motion and its interaction with a vertical wall based on the physical model experiments presented by Arikawa (2015) are investigated and compared. IHFOAM is used as wave generation and absorption boundary condition (Higuera et al., 2013). Three-dimensional simulations are carried out solving Reynolds Averaged Navier Stokes (RANS) with no-turbulence model and with  $k-\epsilon$  and  $k-\omega$  SST (Shear Stress Transport) turbulence models in addition to Large Eddy Simulations (LES). The aim of this study is to understand the contribution from turbulence modeling and compare the numerical wave tanks in long wave motion and their interaction with a vertical wall. The results are further discussed in scope of required accuracy in such engineering applications focusing on computational time.

## OVERVIEW OF THE EXPERIMENTAL STUDIES

In these experiments the time histories of water elevation, velocities and pressures are also measured at different locations in the channel and on the wall with 13 wave gauges, 6 electro-magnetic velocity meters and 10 pressure gauges (Figure 1). The first position of the vertical wall is just above the step, while second position is 2.50 m away from the first position (Figure2 (a) and (b)).

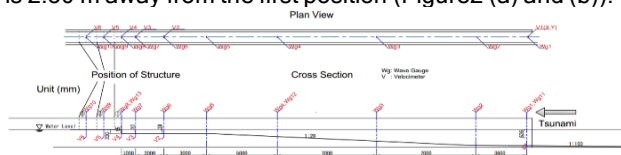


Figure 1 - Cross section and plan view of the experimental setup

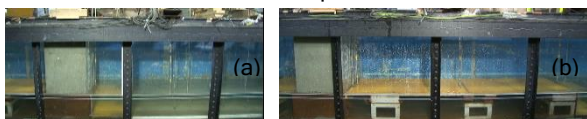


Figure 2 - (a) First position of the vertical wall, (b) Second position of the wall

## NUMERICAL MODELING STUDIES

CADMAS-SURF solves 3D RANS based on porous body model using Volume of fluid (VOF) method. It uses  $k-\epsilon$  model for turbulence. interFoam solver solves the three-dimensional Navier-Stokes equations for two incompressible phases using a finite volume discretization and VOF method. In VOF, each phase is described by a fraction  $\alpha_i$  occupied by the volume of fluid of the material in the cell. In turbulence modeling with two-equation models,  $k-\epsilon$  model is better in free flow area and  $k-\omega$  model is better near the solid boundary. The  $k-\omega$  SST combines

these two models.  $k-\epsilon$  and  $k-\omega$  SST models are selected to use with RANS for comparisons. Moreover, LES captures the large eddies, and models the small eddies with SGS models. For OpenFOAM a total of 4 simulations are performed for each of two different vertical wall positions: i) Laminar, ii) RANS with  $k-\epsilon$ , iii) RANS with  $k-\omega$  SST, iv) LES. For CADMAS-SURF a total of 2 simulations are performed for each of two different vertical wall positions: i) Laminar, ii) RANS with  $k-\epsilon$ . Simulation time is kept as 30 seconds. Comparisons are performed based on time series data, water particle velocity and wave pressure measurements.

## SUMMARY AND CONCLUSION

Preliminary studies show that the results of the interFoam and CADMAS-SURF with all turbulence models are in fairly well agreement with the experimental results along the wave channel. There are some discrepancies in the results in front of the vertical wall because of the extremely high splashes over the vertical wall. Figure 3 shows the spatial waveform comparison. Among all the models it is seen that the LES gives more accurate results both along the channel and on the vertical wall, yet, laminar flow assumption is also found to give acceptable results considering required engineering accuracy in comparison with computational time.



Figure 3 - Spatial waveform comparison of (a) experiment, (b) OpenFOAM and (c) CADMAS-SURF.

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