Development of a fluid-solid multiphase flow simulator by a SPH-DEM coupled method for simulating a seawall destruction due to soil foundation scour

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ABSTRACT

In order to estimate a destruction phenomenon of seawall for prevention and/or mitigation against to the next huge Tsunamis, fluid-soil interaction simulation is strongly required. In this study, ISPH method is applied for fluid simulation while DEM is applied for modelling of soil behaviour. Fluid flow in soil domain is modelled as the permeability flow from a macroscopic viewpoint, and the rest of the water domain is governed by the Navier-Stokes equation as a normal fluid flow. These equations can be generalized by a unified equation proposed by Akbari[1]. However, the application of the unified equation is limited to a fixed soil foundation without any destruction as far as authors know. In our study, mobility of the soil particle is modelled by the DEM, and its resistance force acted on the macroscopic solid particle is given by the unified equation and Wen and Yu[2] model, which can be applied to not only a low void ratio but also a high void ratio as follows.

$$\frac{C_r(\varepsilon)}{\varepsilon}\frac{D\overline{\boldsymbol{v}}_f}{Dt} = -\frac{1}{\bar{\rho}_f}\nabla P + \frac{\boldsymbol{g}}{\varepsilon} + \nu_E(\varepsilon)\nabla^2\overline{\boldsymbol{v}}_f \begin{cases} -a(\varepsilon)\boldsymbol{v}_r - b(\varepsilon)\boldsymbol{v}_r|\boldsymbol{v}_r| & (\varepsilon < 0.8) \\ -\dfrac{3}{4}C_d\dfrac{(1-\varepsilon)\rho_f\boldsymbol{v}_r|\boldsymbol{v}_r|}{d_s}\varepsilon^{-2.7} & (\varepsilon \geq 0.8) \end{cases}$$

There are no direct interactions between the fluid SPH and soil DEM particles, and these two kinds of particle affect each other by receiving an interaction force which can be evaluated from the fluid governing equation. In our study, the macroscopic soil particle is modelled by a sphere particle with a constant radius to reduce the computational costs. A rolling friction model is applied to represent the shape effect of real soil particles with the ideal sphere particles.

A glass beads and water dam-break flow experiment done by Xiaosong Sun et.al[3] is represented by our simulation tool for validation. Our simulation result shows a fairly good agreement with the experimental result. The simulation of the sea wall destruction will be done with this SPH-DEM coupled method for the future work.

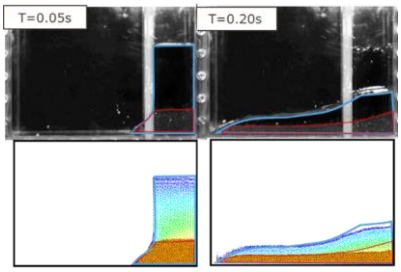

Figure 1. Comparison of the glass beads and water dam-break

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[3] Xiaosong Sun, Mikio Sakai, Yoshinori Yamada, "Three-dimensional simulation of a solid-liquid flow by the DEM-SPH method", *Journal of Computational Physics*, **248,** 147-176 (2013).