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YADE 1D vertical VANS fluid resolution: validations

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ABSTRACT

In the present note, the one-dimensional Volume-Averaged Navier-Stokes (1D VANS) fluid resolution is validated through comparison of analytical poiseuille flow and logarithmic layer. The fluid resolution and its coupling with the DEM is further validated by reproducing the turbulent bedload transport experiments of Frey (Frey, 2014), reproducing the results presented in (Maurin et al., 2015). All these validations can be reproduced using scripts available in YADE source code.

Keywords: Yade; fluid-DEM coupling; 1D VANS; turbulent bedload transport; validations; experimental comparison

1 Introduction

The goal of the present note is to validate the 1D VANS fluid resolution implemented in YADE (Šmilauer et al., 2015). The details about the resolution and how it works in YADE can be found in (Maurin, 2018a) and (Maurin, 2018b). For each of the case tested here, there exist a script that is available in YADE source code, so that it can be reproduced by anyone. The scripts (and post-processing to produce the figures) are available in YADE source code in trunk/examples/HydroForceEngine/validations/.

2 Pure fluid cases

2.1 Poiseuille flow

For a laminar fluid flow between two plates, we can easily derive (see all the fluid mechanics text books) the analytical fluid profile from the Navier-Stokes equations. Setting the turbulence to zero and applying fixed boundaries at the top and at the bottom, figure 1 shows that the fluid resolution in YADE reproduces exactly the analytical solution, validating the resolution and the expression of the different viscous terms.

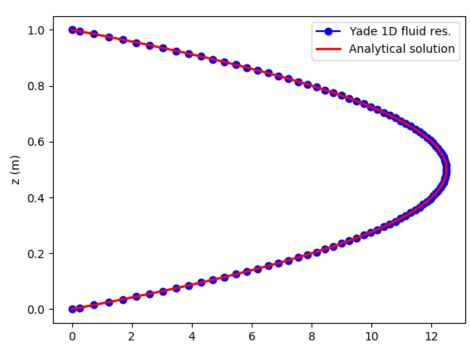

Figure 1. Comparison between the results of YADE 1D fluid resolution and the analytical solution for a poiseuille flow.

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2.2 Log profile

Considering a turbulent boundary layer, we can similarly derive an expression of the fluid profile by assuming a mixing length formulation of the turbulence. In such case, we can obtain analytically the expected fluid profile. Considering a gravity-driven fluid free-surface turbulent flow on a fixed bottom plate, figure 2 shows that the fluid resolution in YADE reproduces very well the analytical solution until the free-surface influences the results. This validates the resolution and the expression of the different turbulent terms.

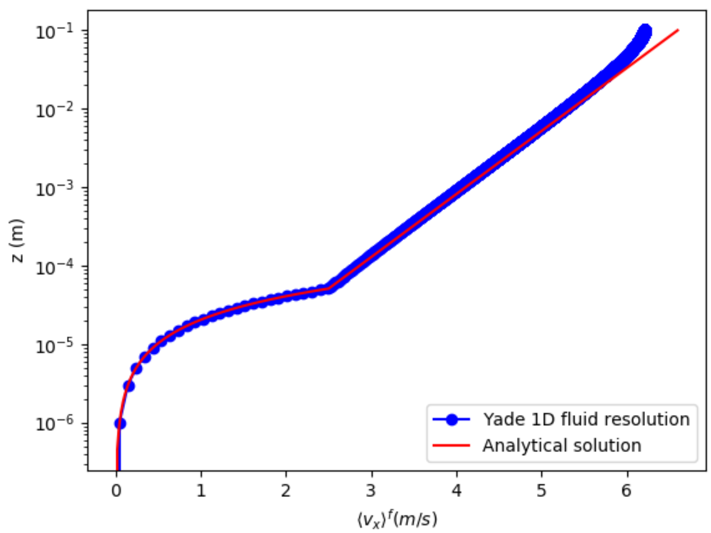

Figure 2. Comparison between the results of YADE 1D fluid resolution and the analytical solution for a turbulent boundary layer.

3 Fluid-DEM coupling

3.1 Experimental comparison to Frey (2014)

In order to validate the fluid resolution and the coupling to the DEM, a comparison has been made with particle-scale experimental data of Frey (Frey, 2014). This has been done in the following paper (Maurin et al., 2015), where we have shown that the coupling reproduces very well the experimental data. Using the code and the coupling implemented in YADE, we reproduce the same simulations than the one made in (Maurin et al., 2015). Figures 3 show that the results are very similar to (Maurin et al., 2015) and compares very well to experiments. Indeed, the solid velocity, solid volume fraction, and transport

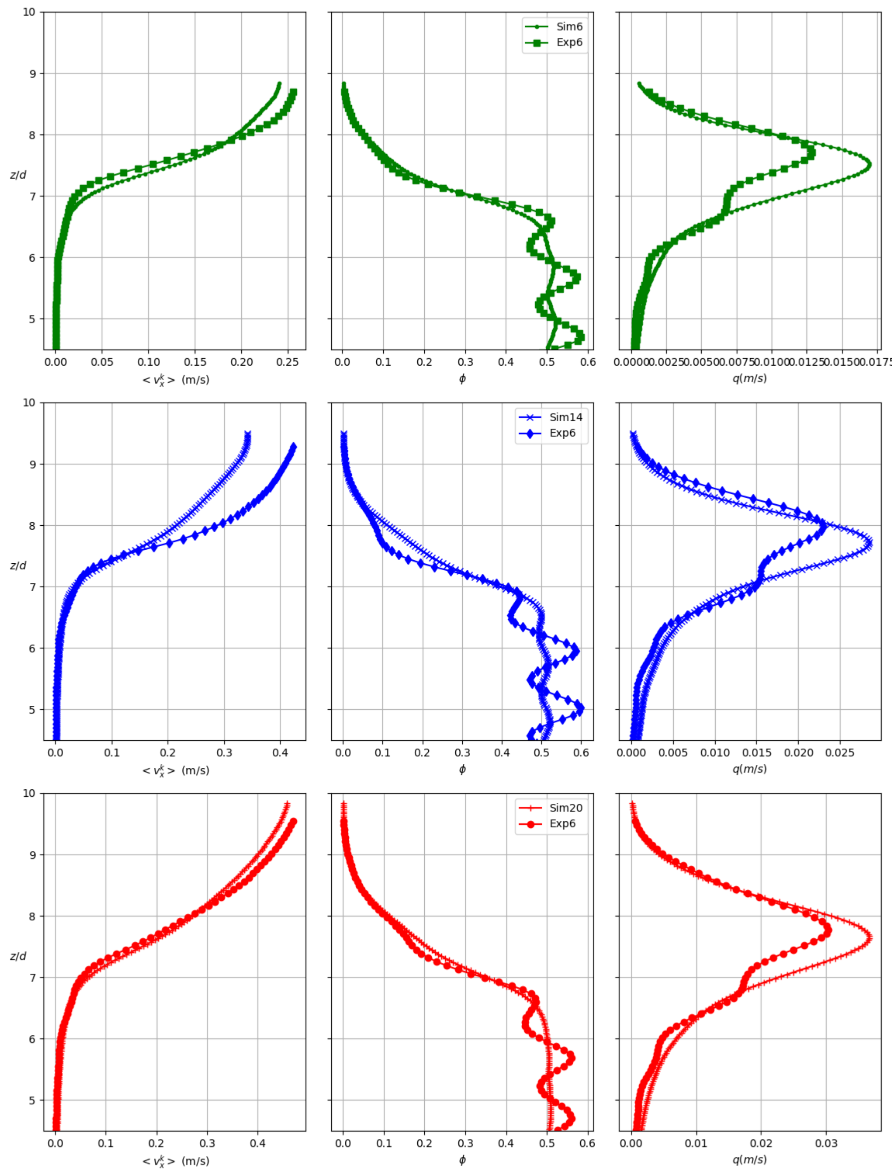

Figure 3. Comparison between the results of fluid-DEM coupling in YADE and experimental data of Frey (Frey, 2014), reproducing the paper of Maurin et al. (Maurin et al., 2015).

rate depth profiles are very similar to the one obtain in the experiments of Frey (Frey, 2014), and can be considered to fall within the variability of the experimental results (see the discussion in (Maurin et al., 2015) for more details). This is the case for three different Shields number, and without fitting any parameter in the simulation. Therefore, this represents a strong validation of the code developed in YADE.

References

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