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NUMERICAL MODELLING OF VISCOUS AND TURBULENT FREE-SURFACE FLOWS USING SMOOTHED PARTICLE HYDRODYNAMICS

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This thesis presents the formulation of a Smoothed Particle Hydrodynamics (SPH) model and its application to a range of engineering applications. The motivation for this research lies in the desire to accurately model viscous and turbulent free-surface flows, including those with complete break-up of the free-surface. At present, boundary element modelling is typically chosen to describe free-surface flows where viscous effects are not important. The Volume of Fluid method is able to model most flow phenomena, but the representation of the free-surface is insufficient for the most complex flows. Current SPH models have shown aptitude for modelling such flows, but there is a noticeable lack of validation carried out in the literature. This thesis includes a thorough investigation into established modelling techniques, extending or developing new techniques where necessary, in order to create a versatile and accurate SPH model for free-surface flows. Where possible, quantitative comparisons with experimental observations have been carried out to ensure a suitable level of accuracy has been achieved.

First, a fairly basic SPH model is constructed through testing its ability to generate and propagate solitary waves in a numerical wave flume. This is succeeded by a thorough investigation into solitary waves breaking on a 5° slope, through which further developments are added to the SPH model. The full process, including overturning, post-breaking behaviour, run-up, and the subsequent hydraulic jump are quantitatively compared with experimental measurements. Finally, the SPH model's ability to establish and maintain a steady-state hydraulic jump is examined. Again, quantitative comparisons with experimental measurements are provided.

The work carried out in this thesis shows that the SPH model can successfully capture violent free surface flows with large deformations from the initial surface geometry. Validation studies demonstrate that SPH can form an important part of model testing for engineering developments involving these types of flows.