Primary Topic: *Sediment dynamics, and sediment-biota/plastics interactions*
Secondary Topic: *Hydrodynamics (waves, tides and surges)*
Student Paper Contest: *y*

NUMERICAL MODELING FOR SCOUR NEAR COFFERDAMS USING EULERIAN TWO-PHASE FLOW MODEL

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1 Introduction

Cofferdams are crucial in construction projects involving water bodies because they create a dry, safe work environment by temporarily diverting or blocking water, allowing for the inspection, repair, and construction of structures like bridges, piers, and dams. Predicting scour near cofferdams is necessary to ensure structural stability by selecting the correct foundation toe depth, preventing undermining due to accelerated flow and turbulence around the structure, and mitigating construction risks and costs associated with unexpected scour-induced damages. Traditionally, the estimation of scour at cofferdam structures has relied on a combination of physical model experiments and empirical predictive methods, often guided by established documents such as HEC-18 and CIRIA reports. While these empirical methods provide a solid foundation, 2D/3D Computational Fluid Dynamics (CFD) is necessary because it provides a more detailed and accurate simulation capturing complex flow patterns and sediment transport processes that are challenging to replicate in physical models and empirical approaches [1].

Several experiments investigating various cofferdam geometries have been conducted at HR Wallingford's General Purpose Flume [2]. These experiments, along with CFD modeling studies, examine how cofferdam design, water depth, and flow speed affect clear-water scour. The primary aim of this research is to develop and validate a Computational Fluid Dynamics (CFD) model using the Two-phase Eulerian approach. This model simulates the interaction between sediment and water around these geometries, enabling accurate prediction of scour depths.

2 Methodology

A two-phase Eulerian solver (sedFoam), simultaneously solves the governing equations for both the fluid (water) and particle (sediment) phases, offering more accurate sediment transport representations than single-phase models. It uses two advanced inter-granular stress models: the Kinetic Theory of Granular Flows, suitable for dilute to moderately concentrated flows by accounting for particle collisions, and the $\mu(I)$ rheology, designed for dense granular flows by relating frictional shear stress to the inertial number I [3].

The cofferdam geometries were modeled using hexahedral cells with refined grid density near critical regions to capture boundary layer effects and local flow features. Simulations were conducted in OpenFOAM v2012. Key performance metrics, including scour depth, sediment

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transport rates, and flow velocity profiles, are compared with experimental observations to evaluate the model's accuracy. However, model calibration is necessary, which is the another objective of the current work. Figure 1 illustrates the bed lowering and sediment accumulation in various areas of the cofferdam geometry after 1500 seconds. This provides insights into the effects of cofferdam design, water depth, and local flow speed on scour.

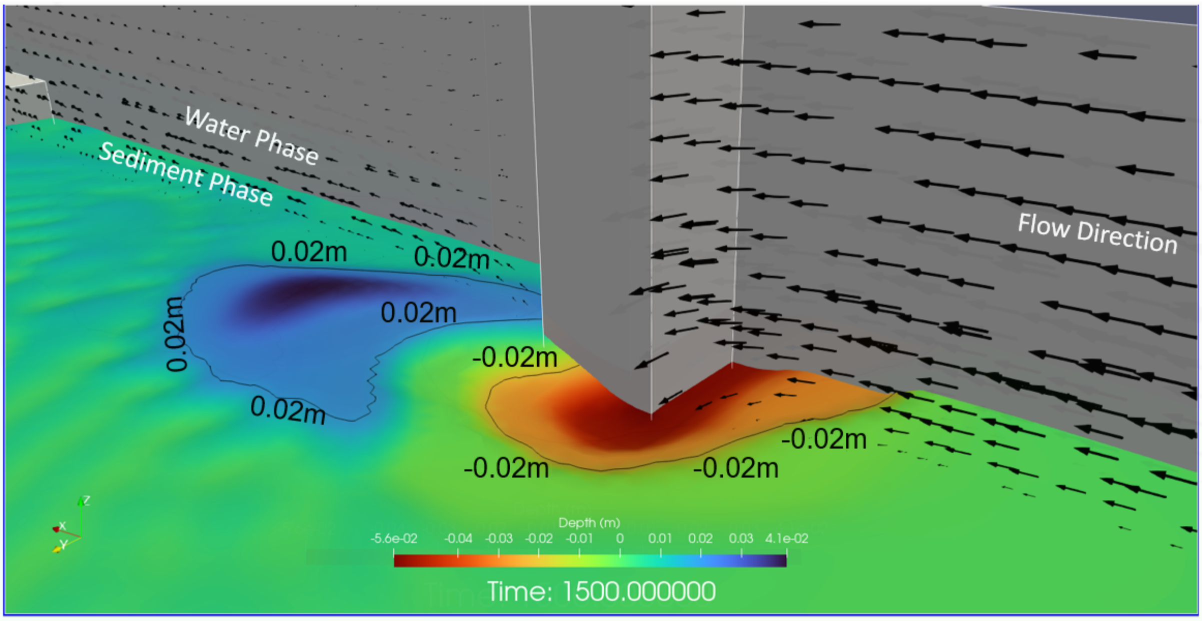

Figure 1: Scour Depth (m) around the cofferdam geometry simulated using two-phase Eulerian approach

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