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Discrete Element Modelling of Floating Debris

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Flash flooding is characterised by high velocity flows which impact vulnerable catchments with little warning time and as such, result in complex flow dynamics which are difficult to replicate through modelling. The impacts of flash flooding can be made yet more severe by the transport of both natural and anthropogenic debris, ranging from tree trunks to vehicles, wheelie bins and even storage containers, the effects of which have been clearly evident during recent UK flooding.

This cargo of debris can have wide reaching effects and result in actual flood impacts which diverge from those predicted. A build-up of debris may lead to partial channel blockage and potential flow rerouting through urban centres. Build-up at bridges and river structures also leads to increased hydraulic loading which may result in damage and possible structural failure.

Predicting the impacts of debris transport; however, is difficult as conventional hydrodynamic modelling schemes do not intrinsically include floating debris within their calculations. Subsequently a new tool has been developed using an emerging approach, which incorporates debris transport through the coupling of two existing modelling techniques.

A 1D hydrodynamic modelling scheme has here been coupled with a 2D discrete element scheme to form a new modelling tool which predicts the motion and flow-interaction of floating debris. Hydraulic forces arising from flow around the object are applied to instigate its motion. Likewise, an equivalent opposing force is applied to fluid cells, enabling backwater effects to be simulated. Shock capturing capabilities make the tool applicable to predicting the complex flow dynamics associated with flash flooding.

The modelling scheme has been applied to experimental case studies where cylindrical wooden dowels are transported by a dam-break wave. These case studies enable validation of the tool's shock capturing capabilities and the coupling technique applied between the two numerical schemes.

The results show that the tool is able to adequately replicate water depth and depth-averaged velocity of a dam-break wave, as well as velocity and displacement of floating cylindrical elements, thus validating its shock capturing capabilities and the coupling technique applied for this simple test case. Future development of the tool will incorporate a 2D hydrodynamic scheme and a 3D discrete element scheme in order to model the more complex processes associated with debris transport.