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Composite Modelling - linking physical and numerical models

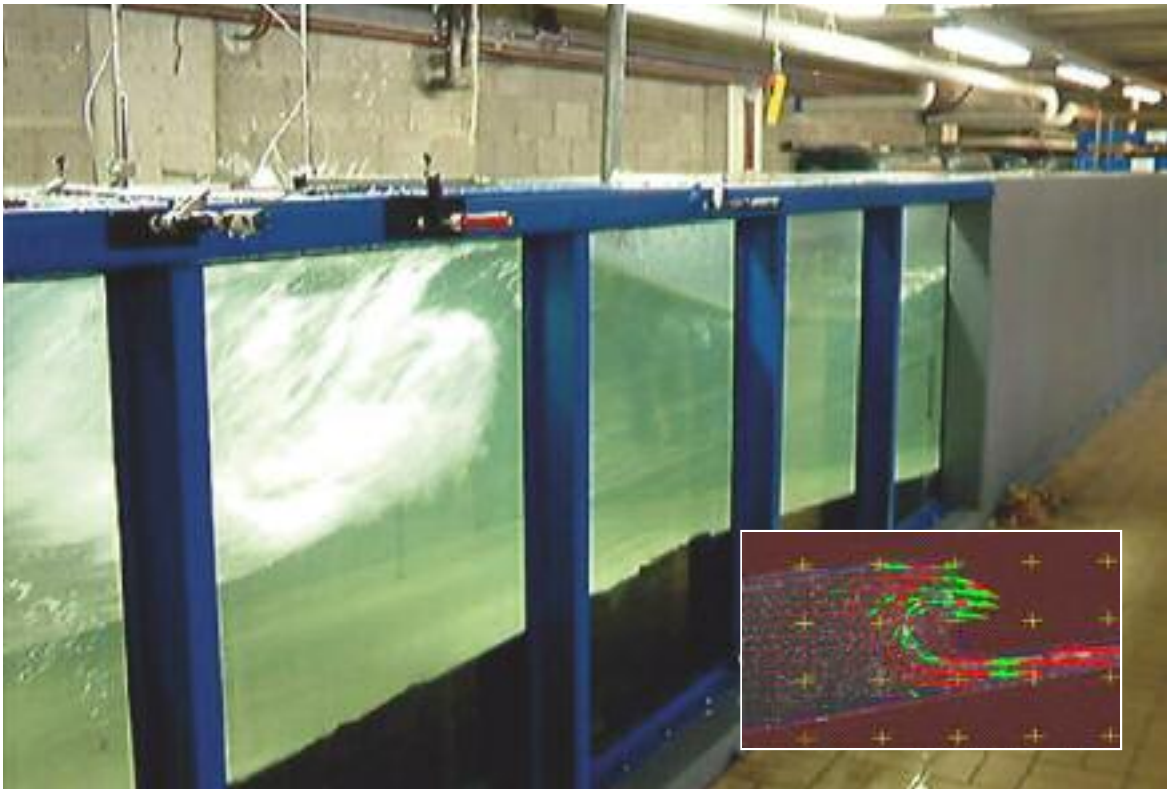
Hydrolink

Composite Modelling - linking

Report of the Composite Modelling Working Group Coastal and Maritime Hydraulics Committee

Composite modelling involves using a combination of physical and numerical models to address a problem. The potential advantages of composite modelling include:

- Extending the range of application of a model;
- Reducing the cost of modelling;
- Optimising the solution, thereby reducing uncertainty.



Picture by Peter Troch

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Dr. James Sutherland is a principal scientist at HR Wallingford in the UK. He has been project manager of consultancy and research projects both in the UK and abroad. Research experience including contributions to EPSRC, Defra, Environment Agency and EC-funded research projects including work on coastal hydrodynamics, scour, broad-scale sediment transport and morphology, the development of physical modelling techniques and beach management.

It is a relatively new topic in hydraulic engineering and was the subject of HYDRALAB research project on the composite modelling of beaches and structures (2006-2010). This project produced a set of guidelines , which were edited and included in a recent IAHR design guide and have been summarised in a paper in JHR . In 2009, the IAHR set up a composite modelling working group to extend the subject to all areas of hydraulics. Members are sharing their experience, seeking to characterise the techniques used and developing best practice of combining physical and numerical models. The Working Group has collected some new test cases (including modelling a dam spillway and various aspects of lock design) and has made an initial characterisation of the composite modelling approaches used .

We have found that composite modelling provides a unique opportunity for researchers and engineers to understand the uncertainties and limitations of both the physical model and the numerical model, since their parallel operation allows for direct comparison and calibration. When complex three-dimensional flow conditions are being modelled, numerical models are often limited in their ability to simulate the flow field in all regions as compared to the physical model. Composite modelling allows for the verification and validation of flow rates, water surface profiles and point velocities within the flow domain and consequently determines specific regions within the numerical model that are not being simulated accurately.

physical and numerical models

There is a range of ways in which physical and numerical models can be combined, including:

- Traditional nesting where a physical model is a detailed representation of a system, which is modelled at a larger scale (and at a more general level) in a numerical model;
- Numerical modelling can assist in the design of physical models by helping to set the location and type of boundary conditions that are to be applied;
- Numerical pre-modelling also provides information about potential problems associated with the theoretical design or proposed design changes to the structure, thereby reducing the number of physical modelling configurations necessary during the physical modelling portion of the study. This pre-modelling effort saves time and money once the physical modelling has commenced.
- Modelling the model can allow a numerical model to be calibrated or corrected using the physical model results. The calibrated or corrected numerical model is then available to undertake additional model runs that would be too time consuming in a physical model or were only considered after the physical model has been decommissioned.
- Physical modelling of hydraulic stability combined with geotechnical numerical modelling of soil strength to determine to extent of a rock scour protection layer around a monopile.

We believe that these techniques should be developed and disseminated. The quantification of the strengths and weaknesses of physical and numerical models should also be encouraged, to replace the usual subjective standards. More and more complex problems are being modelled using physical and numerical models of increasing complexity. However, advantages can still be found in utilizing the complementary strengths of each.

The IAHR working group on Composite Modelling is seeking active members and new case studies on how physical and numerical models can be linked to address problems. We invite anyone interested in finding out more to contact the group coordinator, James Sutherland at j.sutherland@hrwallingford.com

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