Big scanning on a small scale

Understanding the way waves, currents and sediments interact with coastal structures, and the potential impact they can have, is far from simple. 3D laser scanners are helping coastal engineering specialists at HR Wallingford improve the design of such structures.

HR Wallingford works with organisations around the world to solve problems involving water and its interaction with structures and the environment. In many cases, their engineers and scientists apply advanced computational models to investigate these issues. When it comes to structures in the coastal environment, however, the complexity of the processes involved means that scaled physical models still have a critical role to play.

At the organisation’s world-leading physical laboratories in Oxfordshire, UK, physical modelling facilities extend to over 15,000 m². Seven years ago their engineers and scientists began to explore the use of terrestrial laser scanners; today they have been adopted as standard practice.

Breakwaters are structures built to protect coastal infrastructure from the forces of waves. These structures vary in size and composition – at some of the world’s largest ports they can be over 4 km in length. Building a breakwater of any size involves a significant capital investment, and mistakes are costly to fix when problems occur post-construction. Physical models are used to optimise the design of a breakwater in a low-risk environment and help to ensure that it does not fail during its design life.

“A breakwater physical model is typically built at a scale of 1:40,” explains Tom Rigden, HR Wallingford’s Coastal Structures Scientist. “This allows a structure up to one kilometre in length at full size to be built in a wave basin of 25m by 35m. The basin floor is accurately moulded to represent the sea bed so that the waves we create propagate and behave in the same way as they would at site. The model is tested under a variety of storm conditions, ranging from frequent monthly events to more extreme 1:10,000 year events to ensure the structure is able to survive.”

The action of the waves and currents can cause armour units to move around, sometimes a little and sometimes a lot. The challenge for HR Wallingford’s modellers is to quantify the extent of the movement and determine the impact this will have on the performance of the structure. Terrestrial laser scanners have had a big impact on the way that this is done and produce difference plots and surfaces to highlight the most vulnerable areas of the breakwater and show our client where design improvements, such as the use of larger armour, are needed to ensure the breakwater design will be successful.”

The use of terrestrial laser scanners has had a positive impact on HR Wallingford’s physical modelling methods. The improvements in the quantity and quality of the data that they obtain is helping to push forward the boundaries of knowledge and will ultimately lead to advances in coastal physical modelling.

“Analysis used to involve an intensive comparison of overhead photographs and detailed visual inspection and measurement. Several years ago we introduced terrestrial laser scanners to monitor and measure damage to the model structures,” explains Tom. “We scan a model from several locations before testing to provide baseline data. We then repeat the scans after each test. This allows a very high level of detail to be recorded about the model. Each scan point cloud contains several million points, and the point spacing of 2-3 mm allows us to identify where individual rocks (typically as small as 10-50 mm in size) have moved from and to.”

The data is used to produce a series of profiles along the breakwater. Pre- and post-test results are compared to determine where the structure has been damaged or rocks have moved and by how much. The quantity and detail of the data captured allows an accurate assessment of damage to be made, and allows reanalysis of damage to different areas of the breakwater.

“The data is interrogated to extract the information we need to draw conclusions on the model tests,” says Tom. “This can be done even after testing has finished if new areas of interest are identified. We can produce difference plots and surfaces to highlight the most vulnerable areas of the breakwater and show our client where design improvements, such as the use of larger armour, are needed to ensure the breakwater design will be successful.”

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