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The UK Coastal Research Facility 1994–2004

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Introduction

Following the 1989 report of the Coastal Impact Modelling Committee, the Science and Engineering Research Council organized a five-year programme of coastal research, centred on the UK Coastal Research Facility (UKCRF) located at Wallingford. The UKCRF is a large coastal basin co-owned by EPSRC and HR Wallingford Ltd, and has been operating since 1994. It is capable of producing irregular long-crested and short-crested waves at normal or oblique angles of incidence to the beach and is equipped with a current recirculation system to produce steady or time-varying longshore currents. Since the UKCRF opened, it has been used by a variety of research teams to investigate coastal processes. The ICE half-day meeting was held to disseminate information about representative aspects of that research to the wider coastal engineering community. More than 40 delegates from coastal engineering consultant firms, the Environment Agency, local government, industry and universities attended. Nine presentations were given, outlining the results from a selection of the recent experiments in the UKCRF and on the strategy for the next five years. Further details about the UKCRF (including a bibliography) may be found at http://www.hrwallingford.co.uk/facilities/crf.

Presentations

Dr A. G. L. Borthwick of Oxford University described a series of tests carried out to measure the spatial distribution of wave-induced currents and the detailed structure of rip and meandering long-shore currents at a fixed sinusoidal multi-cusped beach. Waves normal to a cusped beach cause near-shore circulation cells, with fan-shaped inflow currents running up the peak of each cusp and narrow jet-like outflow rip currents at cusp troughs. ADV measurements indicated that the rip currents are predominantly horizontal, but oscillatory. Oblique waves were found to produce a stable meandering long-shore current, with a logarithmic near-bed profile.

Mr R. D. MacIver presented work done with Dr R. R. Simons of UCL. Experiments were performed with regular deep-water waves propagating obliquely across a narrow 'jet-like' current. Such currents are typical of nearshore flows observed at tidal inlets or river estuaries. Results show that both wave celerity and height follow the trends predicted by gradually-varying flow theory, but that wave height is modulated by weak reflections at the shear layers of the current. The local wave propagation direction is sensitive to these reflections.

Dr D. Chen (Manchester University) described experimental studies of tidal coastal flows around headlands using PTV, ADV, thermal imager, fluorimeter and LDV. Different flow patterns were obtained over a range of KC numbers, and some three-dimensional turbulent details were recorded. The dispersion of dye and thermal plumes was also measured. One application of the work may be that vortices may be harnessed to carry pollution further away from a sewer outfall. It may become possible to show that there is a minimum distance of outfall required.

Dr J. Sutherland presented work done with Dr T. O'Donoghue when at Aberdeen University. Their parameterizations of wave phase shift on reflection from coastal structures and the reflection coefficient spectra of coastal structures were outlined. The presentation showed how these parameterizations could be used to predict the kinematics in front of a variety of coastal structures and showed how the results were already being used.

Dr A. Chadwick (University of Plymouth) presented work done on a collaborative project with Profesor B. A. O'Connor (Liverpool University) that used a model of part of the Elmer breakwater scheme. The strengths and weaknesses of physical and numerical models in predicting prototype behaviour were examined. The presentation demonstrated that a complex recirculating flow existed behind the breakwaters. Moreover, the effects of wave transmission, beach reflection and mass flux-induced set-up need to be incorporated in numerical model simulations. Equivalently scaled sand and anthracite models produced significantly different beach forms, and no longshore transport occurred.

Dr J. Loveless (Bristol University) described the performance of an alternative detached breakwater scheme in which the crest level of

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the Elmer breakwaters was lowered. The results suggested that there were both cost savings and performance improvements. The sea level set-up effects that can cause problems were also defined and methods of mitigating them suggested.

Dr I. Guymer (Sheffield University) described a series of hydrodynamic and fluorimetric tracing experiments. Conditions of shore normal regular waves, with a range of wave heights, combined with a longshore current were used. Values of on–off shore solute mixing coefficients were determined. An initial attempt to develop a predictive technique to estimate the magnitude of the coefficients was also presented. There is an order of magnitude difference in the mixing associated with breaking and non-breaking waves.

Dr J. Sutherland (HR Wallingford Ltd) gave details of other projects that had been carried out and described the results from two of them. A project on impact loading on vertical walls in directional seas showed how obliquity and directional dispersion reduced the intensity of loading. Wave breaking criteria were established for sea-states including oblique random seas to add to an international database of breaking criteria.

Dr A. G. L. Borthwick then introduced the strategy document for tests in the UKCRF from 1999–2004. This document was put together by the UKCRF User Group, and is intended to highlight areas of research which are of importance and which are suitable for the facility. The presentation covered advances to instrumentation and measurement systems that will be needed to resolve unsteady coastal processes at high spatial resolution in the UKCRF and ideas for important research in the following four areas.

Waves and currents
High-resolution measurements are required of unsteady and turbulent flow hydrodynamics in the surf-zone for a systematic series of test conditions, including steady and unsteady longshore currents at a plane beach, undertow, rip currents and sheared jets. Other areas of importance are wave groups (and the associated long waves), and statistically extreme wave conditions.

Sediment transport
Research effort should be directed towards understanding bed-form development in three dimensions, sediment scaling effects, sediment transport processes, including graded sediment transport, bed profile evolution, erosion at the top of the swash zone, beach nourishment and the influence of multi-directional seas on beach processes.

Pollution and mixing processes
Research is needed on cross-shore transport in regular, random and grouped waves (including the effect of turbulence), the influence of turbulent structures due to bathymetry, mixing and dispersion in multidirectional seas, and in a tidal current with and without waves.

Coastal structures
Topics for consideration include beach response to coastal structures (including shoreline evolution and the effect on longshore drift), three-dimensional hydraulic effects (e.g. reflection, transmission, overtopping and set-up), scour and geotechnical aspects such as groundwater flows and the settling of structures.

Discussion

The discussion centred on the modelling of detached offshore breakwaters. Topics included the suitability of anthracite for large area models and how results could be used with information from other sources (from field studies to numerical models) to produce a better design. The benefits of having high break water permeability to dissipate set-up were expounded, although problems may be caused by sand in-fill decreasing the permeability. The problem of erosion behind submerged breakwaters due to currents caused by transmission and set-up gradients is still considerable, but more research may lead to a solution that is stable in the long term, even though there may be considerable changes over the short term.

The possibility of having basin effects (as well as scale effects) was mentioned. This emphasized the need for judgement in applying results from the facility. A series of basic tests was urged to help with understanding the main processes that occur commonly.