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Physical and Numerical Modelling of Trench Infill

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ABSTRACT

Physical modelling of trench infill, for trenches perpendicular to the flow direction, was undertaken in the Fast Flow Facility at HR Wallingford. Parameters including trench width, flow velocity (including reversing tidal flow), and the presence of berms along the sides of the trench were varied. Following the experiments, a numerical model was constructed with the T_0 bathymetry from the physical model used as the starting numerical model bathymetry, allowing direct comparison between models. Numerical model parameters were tuned to represent the physical modelling results, with the calibrated model then used to predict infill rates for other scenarios modelled in the Fast Flow Facility.

KEY WORDS: Trench; trench infill; sediment transport; erosion; dredging

INTRODUCTION

It is often necessary to construct trenches within the marine environment, whether temporarily for projects such as laying and burying pipelines and cables, or for more long-term projects such as navigation channels, to provide access to ports and harbors.

The construction of sub-sea trenches requires dredging, and, with the costs associated with dredging high, efficiency of operation is of paramount importance. In addition, trenches are often required in regions that experience sediment transport, and trenches are often subject to sediment infill. Therefore, in order to undertake appropriate planning for the construction and maintenance of submarine trenches, engineers require knowledge on the likely rates of sediment infill, and the specific conditions associated with these predictions (Niederoda and Palmer, 1986; Dearnaley, et al., 1999; Lowe, 2010).

In general, infill of the trench occurs primarily due to the reduction in flow velocity that occurs when there is an increase in water depth (caused by the presence of the trench), with the rate of infill often proportional to the amount of sediment carried by the water (Lean, 1980), as the carrying capacity of the water is reduced by the decrease in flow velocity over the trench. However, accurate predictions of the rate of infill are complicated by the uncertainties associated with sediment transport calculations and the difficulties in making accurate field observations, which together make the estimation of infill rates difficult (Knaapen, 2013). These uncertainties in prediction arise predominantly from the variations in sediment characteristics found in natural sediments (e.g. sediment type, density, grain sizes) as well as the important aspect of correctly specifying bed material availability (Mead, 1999).

To contribute to the research that has been reported on the subject of trench infill, a series of physical and numerical modelling experiments were undertaken. Details of the model set-ups are presented below. This study is designed to investigate two aspects of trench infill: infill rate, and trench migration rate.

METHODOLOGY

Physical Modelling

A series of physical modelling experiments were completed in the Fast Flow Facility (http://www.hrwallingford.com/facilities/fast-flow-facility) at HR Wallingford, a 75 m long, 8 m wide, 2.5 m high wave-current-sediment flume (Whitehouse, et al., 2014) capable of generating reversing currents of up to 2 ms^{-1} and waves of up to 1 m H_{Max} or 0.55 m H_s (Fig. 1).

Fig. 1: The main channel of the Fast Flow Facility (left) and one of the initial trench profiles cut in sand (right)