PHYSICAL MODELLING OF PROPELLER SCOUR ON AN ARMOURED SLOPE

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INTRODUCTION

CITIC Pacific Mining (CPM) is proposing to increase throughput at their existing Sino Iron Terminal in Cape Preston, Western Australia, using self-propelled Handysize transshipment shuttle vessels (TSV) instead of dumb barges. Initial assessment using various desktop methods (PIANC, 2015) indicated that the armoured rock slope adjacent to the berth face would incur damage due to wash from the vessel side thrusters and the main propeller. Large scale (13.5:1) physical model tests were undertaken in a 6 m x 15 m x 1.4 m deep basin at UNSW to measure wash velocity and armour stability. The physical modelling demonstrated that the rock slope was more stable than expected, but that some armour was mobilized. Additional tests were also completed to investigate the efficacy of Articulated Concrete Block Mattresses (ACMs) to protect the rock slope from propeller wash.

JET VELOCITY

A large-scale physical model was chosen to better represent the turbulent flow characteristics of the propeller jet. Scale models of the ship propellers were calibrated by adjusting their rpm to reproduce the theoretical efflux velocity adjacent to the propeller face. Efflux velocity and its decay with distance on the jet axis were measured at 100 Hz for several rpm settings using an Acoustic Doppler Velocimeter. When compared with the equations presented in PIANC (2015), the velocity decay profiles agreed well for the bow thrusters but not for the main propeller, where the zone of flow establishment was significantly shorter than predicted by the equations and there was evidence of significant three-dimensional flow.

ARMOUR STABILITY

Armour stability tests on a 3H:2V slope were conducted by modelling twin bow thrusters and both the main propeller and a single stern thruster. Each model test was run for 8 minutes, equivalent to 30 minutes full scale. Movable bed and fixed bed cases were tested to isolate the processes of seabed undermining and direct rock armour displacement from the test section of the slope. The number of rock movements on the test slope was measured (by comparing before and after laser scans).

The rock armour was found to remain more stable for a given wash velocity than predicted by the empirical equations. However, the model test data showed that the cumulative effect of multiple vessel operations would compromise the long term stability of the armoured slope. Articulated Concrete Mattresses (ACMs) of 3 m x 10 m x 0.4 m size overlain on the slope were subsequently tested to investigate their efficacy (Figure 1). Some movement of the mattresses was observed, especially at higher wash velocities. It was seen that interconnecting adjacent mattress sections along their long edges increased their stability.

CONCLUSIONS

Available empirical equations for predicting the stability of rock subjected to propeller wash were seen to be conservative when compared to physical model results. Decay of the propeller jet velocity with distance is accurately predicted by the equations in the case of the scale bow and stern thrusters but was conservative for the wash from the main propeller. The results from the scenarios tested showed that long term breakwater slope stability and vessel navigability would be compromised at the facility. Articulated Concrete-block Mattresses (ACMs) were demonstrated to remain stable when impacted by thruster and main propeller wash from the operation of the Handysize vessel at the berth.

Figure 1 – ACMs in place over the rock slope during the Handysize vessel tests.

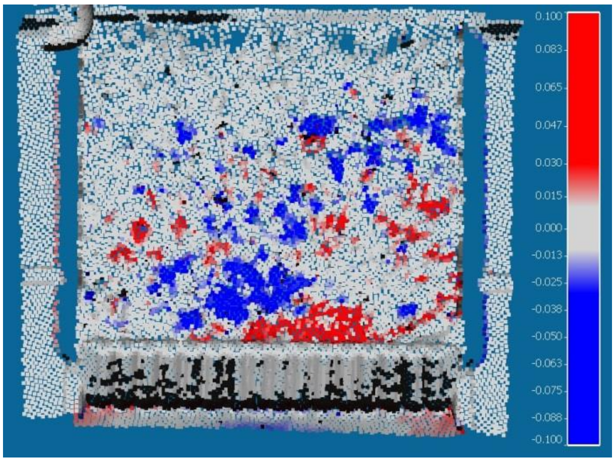

Figure 2 – Processed before and after laser scans of one of the "handysize" tests. Blue shows locations of decreased rock thickness and the red shows increased rock thickness.

REFERENCES

PIANC. (2015) "Guidelines for protecting Berthing Structures from scour caused by ships". Rpt # 180.