Improving our understanding of ship side thruster forces on existing armoured berths through physical modelling of prop-wash

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Abstract
Ship movement without supporting tugboats and the emergence of powerful self-propelled vessels has led to potentially devastating effects on structures that were not designed for jet impacts. Port operators are now left facing a decision of whether to restrict bow and stern thruster operations or to update the structure protection.

The Water Research Laboratory (WRL) in the School of Civil and Environmental Engineering at UNSW Sydney has recently open a dedicated prop-wash facility for the physical modelling of the effects of ship side thruster forces on existing armoured berths and ports. WRL has now undertaken five major port studies at large scales ranging from 1:13.5 to 1:20. Froude scale testing at these scales is unique and ensures that turbulence and drag effects are well reproduced with a high Reynolds number. The scaling rules have ensured adequate turbulence based on coastal engineering scaling rules for armour mass and providing adequate resolution and accuracy for model measurements.

This paper presents several case studies, including different
can be balanced and optimised. While existing guidelines provides generally conservative ana
modelling allows for a greater understanding of each specific port.

Keywords: physical modelling, prop-wash, vessel, port, stability, coastal structures

1. Introduction
Ship movement without supporting tugboats and the emergence of powerful self-propelled vessels has led to potentially devastating effects on port structures that were not designed for direct jet impacts. Modern vessels are often equipped with powerful propulsion systems that can typically create multiple jets with velocities up to 10 m/s directed at port infrastructure or scouring seabed fronting quay walls.

Port operators may need to decide whether to restrict bow and stern thruster operations or to update the protection of the structure. While guidelines exist [1, 2] to help the design process allow for desktop assessment and empirical

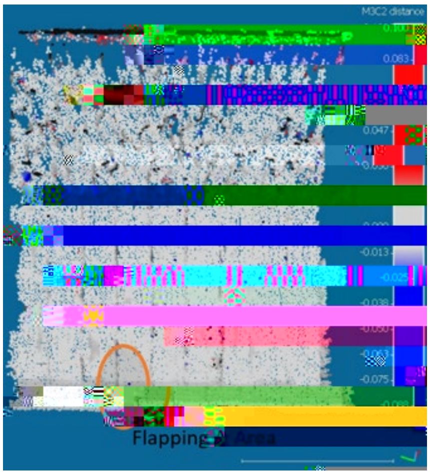
2. Scaling Considerations

All prop-wash models tested at WRL were carried out at a relatively large scale of 1:13.5 to 1:20. T

Figure 5 Photos of a model setup with ADV and underwater cameras

Figure 7

(a) Underwater video footage showing flapping of leading edge of ACMs



(b) 3D FARO scan post test

Figure 10 ACMs moving during testing

This is different from wave damage on coastal structures where rocks can be damaged during down rush of waves (i.e. pulled from structure). Movements of rock on a slope from propeller wash jets were generally observed in the region directly in front of the jet. A 3D laser scan was performed before and after each test to accurately evaluate the damage (Figure 9).

5.2 Rock Bags

Rock bags were usually stable for the conditions tested (Figure 11). As per rocks, the jet pushed the bags up and into the slope resulting in greater stability than originally expected. The bags were susceptible to jets at angles. Also being a single layer, if a bag was moved then large sections of the slope could become unstable. The long-term integrity of the bag fabric was not assessed.

Figure 11 Rock bags on revetment slope in front of bow thruster setup

5.3 Grout Mattresses

Grout mattresses were found to be potentially unstable when propellers were placed above them due to uplift forces. Damages are generally expected to result from jet impact. However, the failure mechanism observed for grout mattresses was due to the uplift of units when located directly under the propeller (Figure 12).

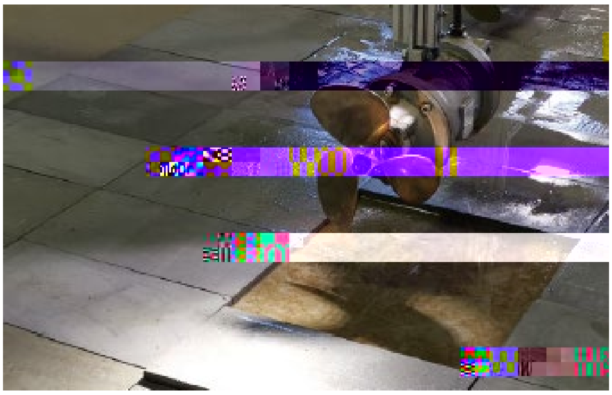


Figure 12 Concrete mattresses located directly under the propeller moved

5.4 Erodible Bed

Testing with an erodible bed showed the formation of a scour hole (Figure 13). The rocks or armour units were observed to fall into the scour hole. The toe of the structure is critical for the stability of a design solution. Whether the armour be ACMs, rocks or rock bags, the structure needed to be flexible enough to slump into this scour hole and avoid undermining. Alternatively, a toe trench needed to be constructed in advance.