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DECAY OF BOW THRUSTER INDUCED NEAR-BED FLOW VELOCITIES AT A VERTICAL QUAY WALL: A FIELD MEASUREMENT

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INTRODUCTION

During berthing operations vessels use bow thruster(s) to improve their manoeuvrability, making them less dependent on the assistance of tugboats. While manoeuvring, the transversal bow thruster jet can reflect on the quay wall and partially be directed towards the bed. At the intersection between the quay wall and the bed, the jet reflects again leading to a highly turbulent and complex flow field (Figure 1). When the bed is left unprotected scour may occur, which can eventually lead to instability of the quay wall (Roubos et al., 2014).

Over the years, the shipping industry has been developing continuously, characterized primarily by the upscaling in size of inland- and sea-going vessels (OECD, 2015; Weenen et al., 2020; Looye, 2021). As a result, vessels have larger draughts, more power and larger thruster diameters leading to higher hydraulic loads on quay walls and bed protections of berthing facilities (Roubos & Verhagen, 2007). To complicate the matter even more, the jet from a transversal bow thruster is confined by the hull of the vessel, the quay wall and the bed. Leading to a complex flow field of the reflected jet and an unknown decay in near-bed flow velocities. Resulting in uncertainties in the design of bed protections, especially in the required width.

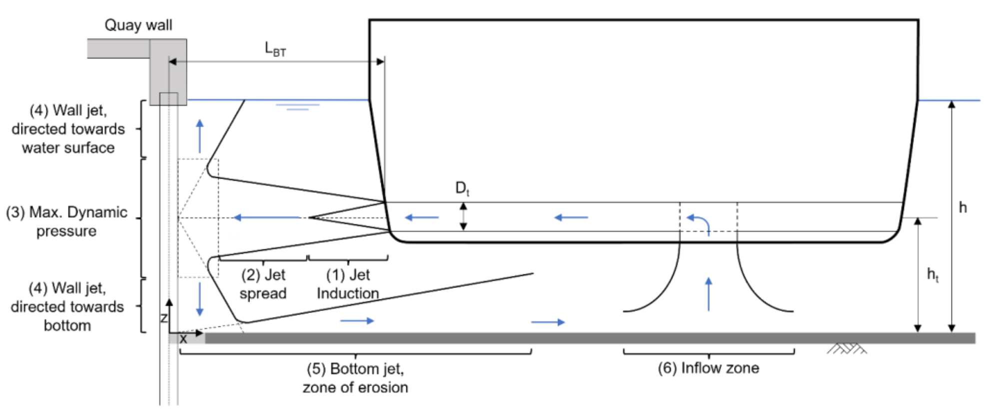

Figure 1: Cross-section of a channel type bow thruster in an inland vessel illustrating the five different flow zones of the reflected bow thruster jet identified by Schmidt (1998). In addition, a sixth inflow zone for channel type bow thrusters as found by Cantoni (2020). It must be noted that these flow zones are a simplified two-dimensional approach of the complex three-dimensional flow.

APPROACH

In this study, the decay of the near-bed flow velocity perpendicular and parallel to the quay wall induced by a 4-channel bow thruster was studied. Field measurements were conducted in the North Sea Port of Gent with the Somtrans XXV, one of the largest inland vessels in Belgium and the Netherlands (CEMT Via Rijnmax vessel). The flow velocities near the bed, induced by the bow thruster, were measured with Acoustic Doppler Velocimeters (ADV) and Ott meters (Ott) placed on multiple locations on the bed. For the flow velocity measurements four main parameters were varied: the applied bow thruster power, quay wall clearance, number of thrusters, and the lateral distance between jet axis and measurement sensors. During the measurements the vessel was moored to the quay wall in a fixated position. Additionally, several measurements were conducted when the vessel was performing a berthing operation or sailing over the measurement sensors. The results were compared with current guidelines and previous research to place the findings in perspective to literature. This was done by normalizing the flow velocity with the theoretical efflux velocity determined according to the formula of Blaauw & Van de Kaa (1978) for ducted propellers.

CONCLUSIONS

The highest (absolute, horizontal and time-averaged) flow velocities were measured near the quay wall, rapidly declining while moving away from the quay. At other positions displaced parallel with the quay wall, the highest flow velocities were not measured directly underneath the bow thruster axis, but more towards the stern of the vessel. Comparison of the measurement results to the Dutch (Blaauw & Van de Kaa, 1978; Verheij, 1983; Blokland, 1996) and German (Fuehrer et al., 1981; Schmidt, 1998) guidelines generally leads to the conclusion that these guidelines are conservative compared to the measured velocities. In addition, the dependency of the velocity on the total travelled distance by the jet as given in the Dutch method is not reflected in the measurement results. Furthermore, fundamentally different outcomes on the influence of the quay wall clearance on the near-bed flow velocity were found. Compared to the berthing and sailing measurements lower flow velocities were measured when the vessel was moored to the quay wall. When the measured near-bed flow velocities are used as the sole input to calculate the required bed protection, significantly smaller rock sizes and asphalt mattress thickness would be necessary to withstand the hydraulic load of the jet in comparison to current guidelines.

For further research, measurements with different vessels and direct measurements of the efflux velocity of the thrusters, which was used the normalize the results, are recommended. Furthermore, the data set acquired through the field measurements in Gent could be used to validate numerical and scale models. Combining these three different methodologies will contribute to a better understanding of the flow field of a reflected jet on a vertical quay wall with the goal of optimizing the design of bed protections.

REFERENCES

Blaauw, H. G., & Van de Kaa, E. J. (1978). Erosion of Bottom and Sloping Banks Caused by the Screw Race of Manoeuvring Ships. *Publ.no.202, Reprint of paper presented at the 7th International Harbour Congress, May 22-26, 1978, Antwerp.*, Delft Hydraulics Laboratory, The Netherlands.

Blokland, T. (1996). Bodembeschermingen belast door schroefstralen. Huidige ontwerpmethodiek. *Gemeentewerken Rotterdam, Ingenieursbureau havenwerken, Rapport 61.00-R94.038*.

Cantoni, I. (2020). *Bowthruster-induced flow on the bottom of a vertical quay wall.* Master's thesis, TU Delft.

Fuehrer, M., Römisch, K., & Engelke, G. (1981). Criteria for dimensioning the bottom and slope protections and for applying the new methods of protecting navigation canals. *PIANC XXVth Congress*.

Looye, N. (2021). *Schaalvergroting binnenvaart (Dutch).* Utrecht: Rijkswaterstaat.

OECD, ITF. (2015). The impact of mega-ships. *https://www.itf-oecd.org/sites/default/files/docs/15cspa_mega-ships.pdf*. International Transport Forum.

Roubos, A., & Verhagen, H. J. (2007). Uncertainties in the design of bed protections near quay walls. *4th International Conference Port Development and Coastal Environment: PDCE 2007, 25-27 September 2007, Varna, Bulgaria*.

Roubos, A., Blokland, T., & van der Plas, T. (2014). *Field tests propeller scour along quay wall.* PIANC World COngress San Francisco.

Schmidt, E. (1998). *Ausbreitungsverhalten und Erosion swirkung eines Bugpropellerstrahls vor einer Kaiwand.* Dissertation am Leichtweiss-Institut für Wasserbau der Technischen Universität Braunschweig.

Verheij, H. J. (1983). The stability of bottom and banks subjected to the velocities in the propeller jet behind ships. *8th Int. Harbour Congress, Antwerp*.

Weenen, R. d., Geest, W. v., Hindriks, I., & Grijspaardt, T. (2020). *Middenlange termijn prognoses voor de binnenvaart (Dutch),* *https://archief.panteia.nl/default/assets/File/Middellange%20termijn%20prognoses%20voor%20het%20ladingvolume%20in%20de%20binnenvaart%202020%20-%202025%2022112020.pdf.* Zoetermeer: Panteia.