Proceedings of the 9th International Conference on Physical Modelling in Coastal Engineering (Coastlab24)
Delft, Netherlands, May 13-16, 2024

Extended Abstract, DOI: 10.59490/coastlab.2024.811

PHYSICAL MODEL STUDY OF STANDING WAVE IMPACT LOADS ON GATES AND DECKS OF THE EXISTING DISCHARGE SLUICES IN THE AFSLUITDIJK

W.C.D. KORTLEVER[1], A. CAPEL[2], I. VAN DER WERF[3], P.L.M. JANSEN[4], W.F. LOUWERSHEIMER[5], H.A. VERVOORN[6]

1 Ministry of Infrastructure and Water Management, Rijkswaterstaat, The Netherlands, Email: wim.kortlever@rws.nl

2 Coastal Structures and Waves, Deltares, The Netherlands, E-mail: alex.capel@deltares.nl

3 Coastal Structures and Waves, Deltares, The Netherlands, E-mail: ivo.vanderwerf@deltares.nl

4 Ministry of Infrastructure and Water Management, Rijkswaterstaat, The Netherlands, Email: peter.jansen@rws.nl

5 Ministry of Infrastructure and Water Management, Rijkswaterstaat, The Netherlands, Email: willemfrederik.louwersheimer@rws.nl

6 Ministry of Infrastructure and Water Management, Rijkswaterstaat, The Netherlands, Email: herald.vervoorn@rws.nl

KEYWORDS: Physical model, hydraulic loads, wave impacts, flood gates, discharge sluices.

1 INTRODUCTION

To anticipate the rising sea level and to meet the increased flood safety standards the Afsluitdijk in the northwest of The Netherlands is currently being reconstructed. The Afsluitdijk is the dam, with a length of 30 km, that closes the IJsselmeer basin, the former Zuiderzee. Outside the dam lie the Waddenzee and the North Sea. The reconstruction of the dam includes the reinforcement of the dam and the raising of the crest level, the renovation of the existing discharge sluices and the building of new pumping stations, discharge sluices and flood gates. Higher design waves and water levels, including the effects of sea level rise, present determining loads for drawing up the strength and stability of these hydraulic structures. One of these loads is the wave impact load on the gates, supporting beams and bridge decks of the discharge sluices. At first, these loads have been calculated using a design approach which has been based on analytical models, only partially validated (Almeida and Hofland, 2020). It showed that these loads due to vertical wave impacts can be higher than the strength of the gates and the existing bridge decks. Therefore, load reduction measures are required. To better predict the wave impact loads, which strongly depend on the configuration of the gates and decks, a physical model study in a wave flume has been carried out at Deltares (Capel and van der Werf, 2023). This abstract is about the results of this model study, focusing on the wave impacts on the existing discharge sluices near Kornwerderzand, because at this location these loads are the highest.

The physical model aimed at the determination of wave impact loads on the bridge decks, the cable duct and the gates of one of the channels of the discharge sluices. As the impact loads for wind waves coming from the Waddenzee had been derived from earlier model tests, this study considered extreme wind waves coming from the IJsselmeer. Figure 1 shows a typical cross-section of the discharge channels, showing the two gates, the North deck and the South deck, and the cable duct (Thijsse, 1972). The width of a discharge channel is 12 m and the decks are 7.15 m above the channel floor. The highest water level is NAP + 2 m (NAP: Amsterdam Ordnance Datum) and the channel floor is at NAP - 4.75 m. So, the maximum water depth is 6.75 m. The cable duct has a width of 2.1 m, and the North Deck and the South Deck have a width of 11.4 m and 11.0 m, respectively. The opening between the North Deck and the South Deck, with the South Gate open, was 1.6 m wide.

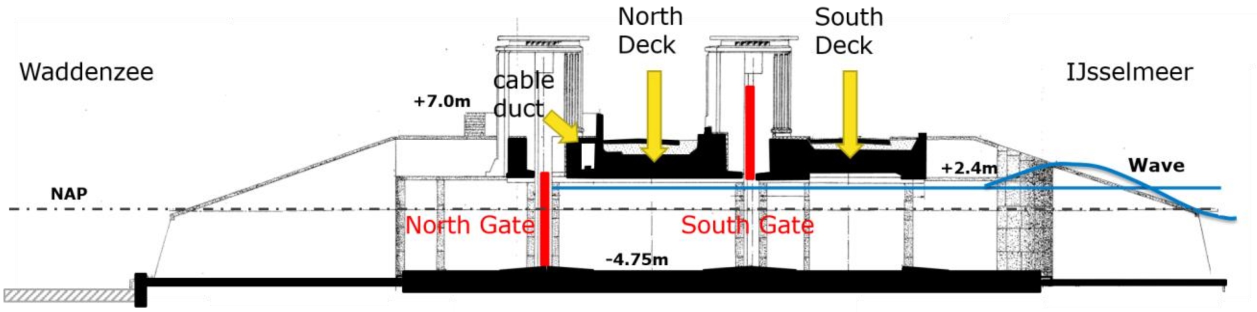

Figure 1. Typical cross-section discharge channel.

1.1 Physical Model

In the Schelde Wave Flume at Deltares, which is 1 m wide, a physical model of one single discharge channel has been built, at a scale of 12 to 1 (see Figure 2, left), using stiff aluminium structures. Thus, one entire channel without the intermediate pillars could be modelled. The gate was represented by a vertical plate with four horizontal beams, one of which was flush with the lower side of the cable duct and the bridge decks. Both wave forces and water pressures were measured on the cable duct and the North Deck, using three force transducers and ten pressure gauges. On the gate only five pressure gauges had been installed.

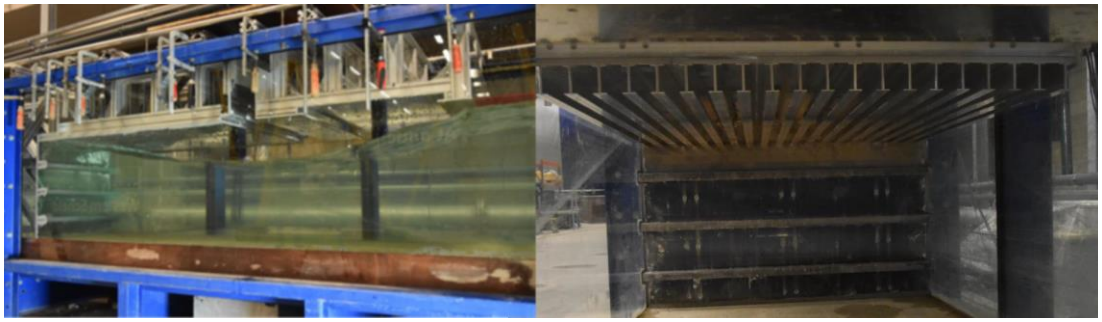

Figure 2. Left: model of gate and decks in wave flume. Right: HEA beams under North Deck.

The model tests included the following four test series:

1. Series T: no opening between North Gate and cable duct.
2. Series U: different openings between North Gate and cable duct: 0.25 m, 0.50 m, 1.00 m.
3. Series V: HEA beams attached to North Deck (see Figure 2, right), zero opening or 1.00 m opening at North Gate.
4. Series Z: reduced channel, South Gate closed, impact loads on South Deck and South Gate, 1.00 m opening at gate.

The tests were carried out with irregular waves, for four different frequencies of exceedance. At each frequency, a wave condition with a high and a wave condition with a low water level were considered, to study the influence of the water level under the decks on the wave impacts.

1.2 Wave Impact Loads

For the different parts of the structure the following results were obtained:

- Cable duct: if there is no opening between the gate and the cable duct the highest impact loads occur at the lower water levels. At the higher water levels, probably due to the entrapped air, the measured forces are lower. In the tests with an opening at the gate, when the air can escape, the forces at the higher water levels increase significantly. Attaching HEA beams again reduces the forces.
- North Deck: the highest forces occur if there is no opening between the gate and the cable duct, caused by the confinement of the waves. Adding an opening reduces the forces. By adding HEA beams the forces remain high.
- North Gate: only with a large opening of 1.00 m the forces on the gate decrease. Using HEA beams the forces on the gate remain high.
- South Gate/South Deck: the maximum forces on the South Gate/South Deck are higher than on the North Gate/Deck, as the waves can more easily propagate when there is only one overhanging deck.

2 CONCLUSIONS

In the physical model tests very high forces were measured due to wave impacts on the decks and the gates of the discharge channel. Also, it shows that the propagation and the reflection of the waves in the channel cannot be captured by the current theoretical models.

ACKNOWLEDGEMENT

The authors would like to thank Project Afsluitdijk for the permission to present the results of this physical model study.

REFERENCES

Capel, A. and Werf, I. van der, 2023. *Afsluitdijk Bestaande Spuimiddelen - Golfklappen IJsselmeer*. Deltares, Delft. (internal report)

De Almeida, E., and Hofland, B., 2020. Validation of pressure-impulse theory for standing wave impact loading on vertical hydraulic

structures with short overhangs, *Coastal Engineering*, 159, 103702.
Thijsse, J. TH., 1972. *Een halve eeuw Zuiderzeewerken*, Tjeenk Willink b.v., Groningen, The Netherlands. ISBN 9001860702