Physical model research on breaking logs for through the gate filling of new Sint-Baafs-Vijve lock

by

Jeroen Vercruysse[1], K. Verelst[1], T. De Mulder[2] and R. Timmermans[3]

EXTENDED ABSTRACT

Most inland navigation locks in the Flemish region of Belgium have a lift height limited to 2-3 m. Therefore, openings integrated in the lock gate sealed by vertical lift valves or butterfly valves are commonly used as lock levelling system. To improve the spreading and energy dissipation of the filling jets and hence reduce the hydrodynamic forces on the moored ships, breaking logs (also referred to as energy dissipation bars) might be mounted at the downstream side of the gate openings. Beem et al. (2000) provide some Dutch design guidelines:(1) The breaking logs should block at least 50% of the gross cross-sectional area at the downstream side of the gate openings. (2) The net area available for the flow at the downstream side should be larger than the area at the upstream side of the gate openings, in order for the largest flow velocity to occur inside rather than outside the gate opening. (3) To prevent floating debris getting stuck in the gate openings, the smallest opening between breaking logs needs to be larger than 30 cm.

Since the shaping of a gate opening across the thickness of a steel gate and the integration of the valves are somewhat country-specific, it was decided to set up a generic physical model at Flanders Hydraulics Research (Antwerp, Belgium) aiming at determining the effect of breaking logs on the flow inside the lock chamber and optimization of the breaking log configurations adopted in Flanders (Verelst et al., 2016).

In this contribution, an account will be given of the specific research carried out in this model during the design of the levelling system of the new lock of Sint-Baafs-Vijve (river Lys, Belgium). This new lock will have a chamber length and width of 260.6 m and 16.0 m, respectively. The design lift height is 2.39 m and the design ship is a CEMT class Vb push-tow convoy. Mitre gates will be used in the upper, intermediate and downstream lock heads. The levelling system consists of 3 rectangular openings, sealed with vertical lift valves, in each mitre gate leaf, hence 6 levelling openings per lock head. The cross-sectional dimensions (width x height) of a gate opening varies across the thickness of a gate leaf: 1.89 m x 1.05 m at the upstream skin plate and 2.40 m x 1.64 m at the downstream skin plate.

During the physical model research, 4 different configurations were tested. The definition of the tested configurations was supervised by both hydraulic engineers and structural engineers involved in steel gate design, in order to be able to assess the hydraulic performance of a given configuration, as well as (dis)advantages in terms of structural realization and maintenance of the gate. For reference purposes, the first configuration did not have any breaking logs. The second configuration comprises 7 breaking logs and is characterized by a blockage of 44 % and meets only the second of the above-mentioned Dutch guidelines. The next two configurations comprises 5 respectively 3 breaking logs and are characterized by a blockage of 31%, respectively 25 %. It is obvious that the latter two configurations do not meet the first Dutch guideline, but they do meet the second and third ones. The geometry of the four tested configurations is presented in Figure 1.

---

[1] Flanders Hydraulics Research, Department Mobility and Public Works, Flemish Government, Antwerp, Belgium (Jeroen.Vercruysse@mow.vlaanderen.be, Kristof.Verelst@mow.vlaanderen.be)

[2] Hydraulics Laboratory, Department of Civil Engineering, Ghent University, Ghent, Belgium (TomFO.DeMulder@UGent.be)

[3] Division Concrete and Steel Expertise, Department Mobility and Public Works, Flemish Government, Brussels, Belgium (Robin.Timmermans@mow.vlaanderen.be)

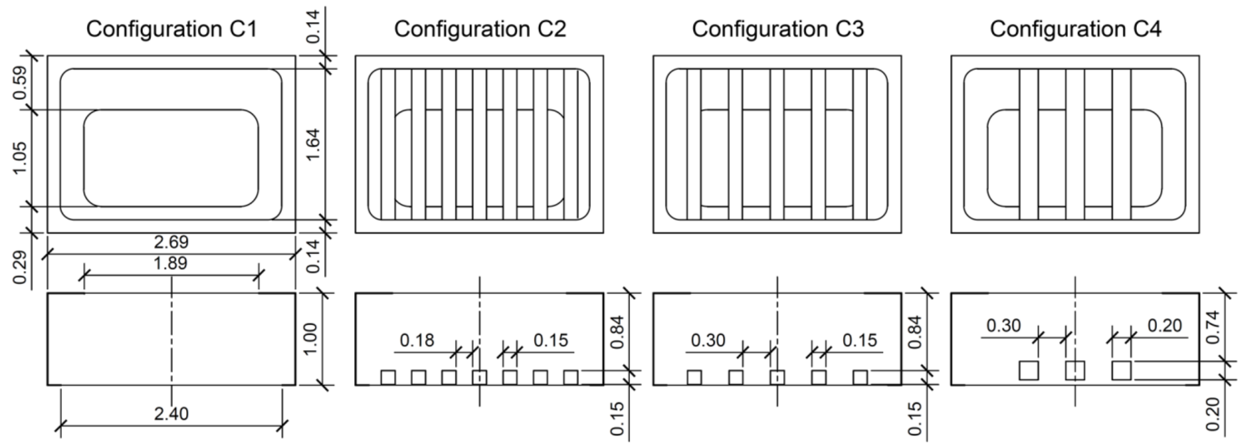

Figure 1: Tested configurations

At first the discharge coefficients of the configurations were determined, for valve openings ranging between 20 % and 100 % of the total valve lifting height. It turned out that the influence of the breaking logs on the discharge coefficient was negligible for valve openings below 50 % and limited for higher valve openings. The manual of the software Lockfill (Deltares, 2015) recommends the use of values between 0.60 and 0.90 for the discharge coefficient. The discharge coefficients obtained from the present physical model tests are well within this range. The value 0.90 corresponds to the lower relative valve openings and the value 0.60 to the higher ones.

Secondly, the effect of breaking logs on the spreading of a filling jet was studied. To this end, the velocity fields associated to a filling jet were measured by means of a dense grid of pointwise velocities, using an ADV device attached to an automated traverse system. In addition to the velocity measurements, flow patterns in the lock chamber were also visualized by means of dye injection. When adding breaking logs, the spreading of the filling jet in the vertical direction increased and the maximum velocity on the centerline of the inlet opening is reduced with 40 to 50 %, depending on the geometry of the breaking logs. The lowest velocities were achieved with the configuration with the least blockage of the gate opening at the downstream skin plate, i.e. the configuration with three breaking logs. The research revealed that the exact positioning of the breaking logs is more important for the spreading of the filling jets than the amount of blockage of the opening.

1. REFERENCES

Beem, R.C.A.; Boogaard, A.; Glerum, A.; de Graaf, M.A.; Henneberque, S.D.; Hiddinga, P.H.; Kranenburg, D.; van der Meer, M.T.J.; Nagtegaal, G.; Van der Paverd, M.; Smink, L.M.C.; Vrijburcht, A.; Weijers, J. (2000). Design of locks. Ministery of Transport, Public Works and Water Management. Civil Engineering Division: Utrecht

Deltares. (2015). LOCKFILL. User and Technical manual. version 0.00 8 July 2015