DESIGN AND FABRICATION OF ROLLING GATES – PIANC WG 173

by

Dr. Matthias Schäfers[1]

1. INTRODUCTION

The aim and purpose of the WG 173 report is to determine technological guidelines for the design, fabrication, construction, operation and maintenance of both rolling gates and movable bridges. Currently, rolling gates are a nearly unanimous choice in navigation locks with chambers wider than about 40 m. Rolling gates are ideal for applications that require handling a differential head from both upstream and downstream directions. For this reason, rolling gates are commonly used for locks subject to tidal changes and storm tides such as sea locks.

2. ROLLING GATE SUPPORTS

Rolling gates utilizing the wheelbarrow design are the largest in world. In a wheelbarrow gate, one carriage is placed under the gate and one at the top level of the gate on the operating machinery side. In the conventional support system, there are two undercarriage assemblies arranged near the gate ends and both carriages are under the gate. The disadvantages of the wheelbarrow type gate are advantages of a conventionally supported gate with two under carriages and vice-versa. For a conventional support system, the loads for all anticipated conditions of a gate under varying conditions may be set in a manner that load distribution will not change due to varying water levels. The lower lateral stability due to the bearing of a gate at its bottom is to be considered and will result in a higher load on the lateral guide of the gates. In a “wheel barrow system”, the rollers of the upper carriage are above water and the mechanical bearings of the wheels are not subjected to water pressure. An extended lifetime is anticipated for the upper carriage since the drive components are all out of the water. The wheels are easily inspected and maintained.

3. ROLLING GATE DESIGN

Rolling gates are generally designed as buoyant types to help reduce operating loads and support the gate load. For gate systems in areas with flood risk, these gates are sometimes over ballasted to ensure buoyancy even for storm tide periods. The gates, which are over ballasted for storm tides, must be appropriately emptied to reach their operating weight after a storm tide. Buoyancy tanks also allow the gate to be raised off the carriages by flotation to allow maintenance and inspection of the rails and carriages. The gates themselves may be transported to a dry dock for maintenance. The buoyancy tank arrangement depends on the required floating depth to float the gates to different positions. If the lock chamber is to be filled through the gate, space must be provided to locate filling valves. These must generally be located beneath the buoyancy tanks to achieve the filling in appropriate water depth to avoid extensive waves on the water surface. In order to ensure sufficient floating stability, additional ballast should be located as close to the gate bottom as possible.

A rolling gate will be fatigue-stressed by the change in differential water levels in the impounded condition and balanced water level during gate opening. To avoid fatigue cracks, a thorough fatigue investigation and an appropriate selection of material toughness is required. The selection of material strengths must also take the influence of strain rates due to waves and ship collision, if any, into account. Strain rates

[1] IRS-Stahlwasserbau-Consutling AG, schaefers@irs-stahlwasserbau.de

must also be considered for anti-collision devices mounted on a rolling gate. Many components of a rolling gate are subjected to fatigue and wear, in particular the carriages and rail tracks. Fatigue and wear are especially critical in this regard, since they are not apparent in normal operation and damage can only be detected during a subsequent scheduled inspection. Wear and fatigue must be considered in interaction in the presence of corrosive media. Protected systems, in which undercarriages run in a dry environment, have proven useful. Cameras and inspection openings may also be provided for inspection.

A typical operating speed of a rolling gate is 0.3 meters per second, but this can vary depending on the size of the gate. A rolling gate carries hydraulic lateral loads not only in the closed position, but also when moving or when in recess. These loads include loads by residual water heads at the end of filling and emptying, loads by wind and waves, loads by currents and tidal forces in an open chamber, and loads by currents as result of salt and fresh water exchange. The guiding systems should not interfere with the sealing system in the closed position of the gate due to high water loads in this position. This might be realized by a spring system or possibly a recess in the rail.

The skinplate of a rolling gate is dimensioned to serve as the effective flange of the main supporting structural framing and as the plate that retains the water pressure acting upon the panels. Shear forces will be transmitted through the drive-track on top of the gate, the top plate of the buoyancy chamber, and the lower plate of the buoyancy chamber. For very tall gates, an additional buoyancy chamber for shear force transmission could be useful. Rolling gates usually have the same manufacturing requirements as other hydraulic steel structures. Particular requirements result from the size of the gate. Often the gate will be built in single segments or blocks and afterwards welded together at another location. For this reason, the accuracy requirements for the single segments must be appropriate when welded together. The tolerance requirements for misalignments from plate positions should be higher than for bridge construction or for ship building, due to the extraordinary high fatigue loads and the scheduled lifetime of the gates.

4. ROLLING GATE MANUFACTURING AND TRANSPORT

Based on the water depth, the draft of the gate, the draft of the available cranes, etc. the gate might be manufactured in the vertical position or the horizontal position. For horizontally manufactured gates, an appropriate method to erect the gate must be developed. For raising, both the assembly workshop and the place of installation need to considered and selected accordingly.

Rolling gates may independently float for transport from the manufacturing workshop to the place of installation depending on distance and the type of waterway. However, rolling gates are also often transferred from the manufacturing workshop to the place of installation on pontoons across the open sea. Floating stability criteria are generally not sufficient to transport the gates across the open sea for long distances. There are different methods for unloading: heavy-load vehicles, floating cranes or by making submersible pontoons buoyant.

Gates may also be installed in their recesses in dry or in wet conditions. For dry installation, the gates are hydraulically lifted from their bracing and placed on heavy-load vehicles. The advantage of this procedure is the visibility of the gate over its entire height. The carriages may be moved very slowly and precisely. For in-the-wet installation, the advantage is that the owner can test the floating stability of the gate for future gate removal and replacement.

Wet installation is very inexpensive, however requires the availability of tugboats and experienced tugboat captains who are capable of performing these activities with the required accuracy. When planning the installation procedure, the different steps and inaccuracies must be investigated in detail; this also includes the tolerances of the lock head concrete structures and the gate steel structures, the floating position of the gate with inclinations resulting from ballasting inaccuracies, wind and waves, tugboat captain capabilities, etc. Which combination of the above-described methods is the least expensive strongly depends on the actual availability of staff, equipment and facilities.

REFERENCES

PIANC. (2017). Report of Working Group 173: Movable Bridges and Rolling Gates, Design, Maintenance and Operation Lessons Learned, PIANC, Brussels.