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Dresdner Wasserbauliche Mitteilungen

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1 Abstract

The present paper discusses the problem of carrying on winter-season repairs of the Oder chamber locks, exemplified by the lock at Ratowice. We present the subsequent stages of upgrading the lock and give the technical solutions referring to dismantling, concrete, mechanical and anti-corrosion work.

2 Introduction

The Oder is one of Poland's two biggest rivers. Its length is 854 km. Compared to other European rivers of similar catchment area size, the Oder is a water-scanty river and, moreover, exhibits highly diversified flow values. For instance, the maximal-to-minimal flow ratio exceeds 200, which is many times as high as that of such rivers as the Rhine, Danube or Rhône in their upper courses. While in the summer-autumn seasons there frequently occurs low water, the Oder exhibits violent, difficult to foresee, flood waves.

Despite this, the Oder has been used for power-generating and transport purposes for ages. As early as in the 13th century, the Oder waters were dammed by about twenty weirs, which used to power undershot water-wheels. Until the 18th century, the navigation took place only locally due to difficult navigational conditions chiefly caused by those weirs and local shoals [5].

As the Oder valley was being increasingly populated, the high water bed was narrowed by building in formerly free flow areas. Severe floods forced the administration to make a decision to regulate the river bed to safely let the flood waters through and stabilise the bed. Intense work was commenced after 1746, by performing cross-cuts and removing obstacles. Finally, the river course was shortened by 177 km, i.e. 22%. Nearly all of the weirs were pulled down and only those in Wrocław, Oława and Opole, still existing today, were left. Then, for regulation purposes, fascine structures were begun to be applied, the peak of which occurred in 1791-1819.

The proper planned regulation was started after the Bogumin Protocol had been signed in 1819, the principal assumptions of which were to minimise the harmful effects of the cross-cuts by creating a winding route, conforming to the nature, remove the shoals from the main stream and develop a downstream-growing normal width for the mean annual flow. Intense regulatory work, performed particularly intensively in the second half of the 19th century, failed to bring about the expected results. Admittedly, the navigability for 400 t barges was attained along the section downstream Wrocław, but the navigation route upstream Wrocław was still not accessible to bigger vessels.

Hence, a decision was made to canalise the river section from Koźle to Wrocław. First, in 1881-1895, twelve water-stages were built along the section from Koźle to the mouth of the Nysa Kłodzka river, thereby canalising over 80 km of the Oder. The particular steps included a Poiré-type hinget weir and a lock 55 x 9.60 m in size. Then, in 1907-1915, in a similar way, the Oder section from the mouth of the Nysa Kłodzka river to Wrocław was canalised and, in 1908-1912, beside the small locks, additional 187 x 9.60 m traction locks were constructed to allow navigation of 1000 t vessels between Wrocław and Koźle.

After World War II, in 1958, the water-stage at Brzeg Dolny was built, thereby lengthening the section of the canalised Oder to 187 km. The damming on the weirs ensured warranted transit depth equal to 180 cm along this section.

Summing up the work of generations of hydroengineers done throughout the past 200 hundred years, The Oder Waterway equals 643 km along the section Koźle-Dąbie Lake in Szczecin and, if we include the Gliwice Canal, elongating this route from Koźle to Gliwice, and a ca. 6 km long Kędzierzyn Canal, — 690 kilometres. This is a relatively long waterway section, which requires permanent maintenance.

Due to a bad technical condition and operating difficulties at the water stages built on the turn of the 19th and 20th centuries, in 1969 the upgrading of the canalised Oder section from Koźle to Różanka in Wrocław was started. The old hinget weirs were replaced first by sector weirs and presently by flap weirs. In parallel, the refurbishment of the chamber locks has been carried on. In this way constant parameters of the waterway are maintained. After being upgraded, the canalised Oder section from Koźle to Brzeg Dolny will be adapted to the navigation of over 1000 t barges.

The refurbishment work on the chamber locks can only be performed during navigational breaks, which typically last from December 15th to March 15th, i.e. during the winter season, when practically always the river icing occurs. It is a relatively short time for a lock overhaul. This is why it is done in stages. Later on we will present the process of a typical refurbishment, exemplified with a chosen object — the Ratowice Lock.

3 Repair of the Ratowice Lock

3.1 A description of the structure before the repair

Together with a new flap weir, put in operation in 1996, the chamber lock makes up a water-stage, located at 227+400 km of the Oder river. Out of the eighteen water stages on the canalised Oder upstream Wrocław, it is only the Ratowice Lock that has only one lock. Therefore, the Ratowice Water-Stage is a sensitivity to this waterway section, hence the technical condition of the lock is of utmost importance in maintaining navigational continuity.

The main parameters of the lock include: length — 187.8 m, width — 9.60 m. The sloping on the lock is 2.40 m. The ordinates of the upstream and downstream heads were 125.65 m and 124.20 m above sea level, respectively, and the ordinates of the thresholds — 119.96 m and 118.50 m, respectively. The level at which navigation is still possible is 124.53 m above sea level at the downstream stand. Such a condition hindered navigation remarkably as water flooded the lock platform at higher water levels (Fig. 1).

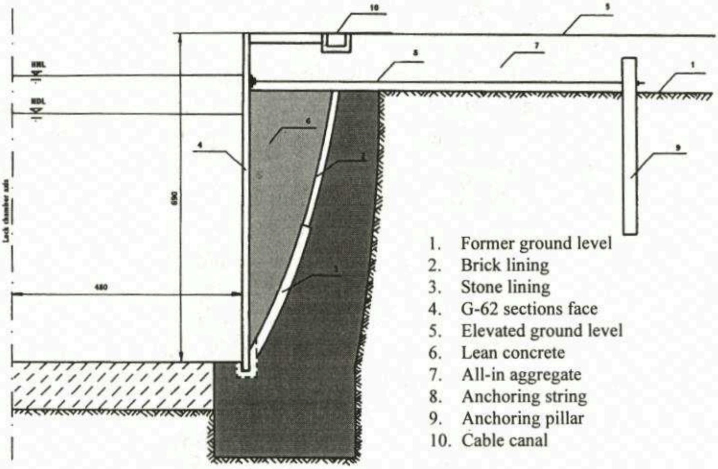

Fig. 1: Lock chamber's cross section

Both lock heads are massive structures built of clinker brick, constituting the wall face, concrete filling up their insides and granite cut stone shaping the corners. The foundation is a concrete slab, the thickness of which ranges 2.0-2.6 metres. Both parts of the heads, left and right, house short 2.0 x 2.0 m flow canals closed with steel wedges, and repair closure recesses. The main closures of the heads are support steel gates. The support gates and the wedges in the flow canals were driven by requisite mechanisms. The repair closures were needle-type.

The lock walls were made of concrete and shaped appropriately to the loads evoked by ground pressure (Fig. 1), which minimised the structure's weight in this way. The face of the wall downstream part was made of granite cut-stone and the upstream — of clinker brick. The bottom slab, 1 metre in thickness, was made of concrete.

Before the repair, the general technical condition of the lock was unsatisfactory. Frequent breakdowns of the mechanisms driving the gates and flood canal closures caused much operating difficulty. Mechanical damage to the very gates and their progressing corrosion actually threatened safe operation of the object. Also the clinker brick lining was damaged, extensive cracking of the walls occurred.

3.2 Repair scope

The bad technical condition of the lock clearly determined the repair timing [4]. The decision made was to perform a general overhaul which, due to an extensive schedule, was performed in three stages, i.e. in 1990 - 1991, 1993 - 1994 and 1995 - 1996. The repair work was started from reconstructing the left wall of the lock chamber, then the downstream and, finally, upstream heads were refurbished. The right wall was not refurbished due to the envisaged addition of the other chamber lock, which is to be immediately adjacent to the old one. The design solutions assume that the two neighbouring walls will be joined together.

The repair of the lock's left wall included facing by means of G-62 steel piling sections, elevating the platform level to the ordinate 125.40 m above sea level and constructing a cable canal (Fig. 1). The scope of the repair of the two heads was identical and included the replacement of the support gates and the flow canal wedges alongside with their drive mechanisms, a reconstruction of the heads, facing them with G-62 steel piling sections and building cable canals for distributing the wiring for the feeding, drive and signalling systems. The reconstruction of the heads consisted of an elongation and elevation of the lock head top and a change of wedge shaft dimensions. The upstream head was elevated to the ordinate 126.25 m above sea level and the downstream one — to 124.40. Such an elevation of the heads allowed for the installation of typical Ib support gates, meeting the condition of the minimum elevation of the lock top over the level of normal damming, thereby eliminating the threat of flooding the platform and the servo motor's and the upper bearing's cavities. The elongation of the head by 1.22 rendered it possible to build new recesses for standardised flashboard repair closures. The increase of the size of the existing wedge shaft allowed placing a typical steel walling of the wedge shaft. The work connected with the refurbishment of the lock's wall required high working discipline and a strict technological regime. Due to the complexity and variety of the work to be performed, the effective repair of the lock's heads meant the involvement of more measures and resources offered by dedicated contractors. Since the type of repair work on the lock's wall is the same as part of the repair work on the heads, later in this paper the authors will focus on describing the refurbishment of one of the lock's heads — the upstream head.

3.3 A description of the refurbishment's particular stages

The repair of the upstream head was begun with piling a sheet wall 1.22 m from the lock's head. During the construction, the sheet wall acted as a partition and presently its extreme parts make the upstream head wall face. After the repair closures had been put up, water from the entire lock was pumped out.

Then all of the unusable devices on the head were dismantled, including the support gates, gate upper bearings together with the bases, lower bearing pivots, drive mechanisms, wedges and their counterbalance weights and casings, as well as platform switchgears. The bearing bases and pivots, hammered out of the head top were meant for re-use. Then the clinker brick face was hammered out down to 0.30 m and all necessary openings for designed recesses and wedge shaft walling were made. In the bottom of the lock, grooves for wall face girts were made. The demolition work was performed traditionally and by means of the firing method.

The next stage of the refurbishment included assembly and reinforcement activities. In the groove hammered in the bottom and on the walls (Fig. 2), the support girts for wall facing were fixed. The lower girt was made of angle steel 200 x 200 x 20 and the structure of the upper girt — of a 160 c-bar and 120 x 120 x 20 angle steel, fixed in the lock's head. Then, in the wall face, wall upstream elongation reinforcement anchoring bars were fixed. After the groove under the lower girt was filled with concrete and when the concrete had hardened, the wall face was put up. The G-62 sections, which were supposed to make the facing, had been pre-cut to the appropriate length, sand-blasted and coated with an anti-corrosion paint. The inner side of the sections was fitted with — appropriately bent — welded reinforcement bars ensuring a better fastening of the facing. The sections, put up sequentially, were welded to the girts and then joined together with a butt joint along their entire height. The top of the lining was finished with a girt made of 200 x 100 x 12 angle steel. While putting up the facing, the walling of flow canals inlets and outlets, on-wall bollards and repair needle closure recesses were made. The subsequent work included: putting up the wedge shaft in the flow canal, insertion of the gate recess and upper bearing casings, putting up the reinforcement, recess furniture, all necessary boarding, fixing the servo motor bases and pillars, as well as all necessary steel markers. After all the work specified above had been done, concrete work started.

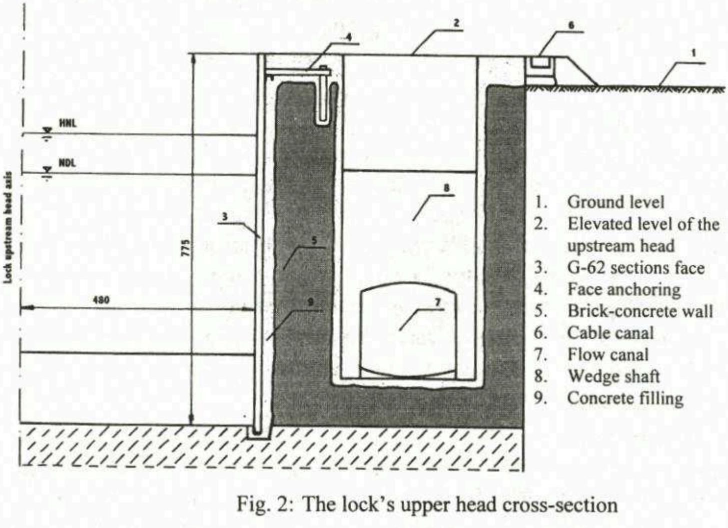

Fig. 2: The lock's upper head cross-section

The concrete work done at the Ratowice Lock was directly supervised by the Institute of Geotechnics and Hydrotechnics, Wrocław Technical University [2], [3]. The main technological problem was to as much as possible shorten the concrete work duration under the circumstances of alternating negative and positive temperatures. The solution of this problem required looking into the following issues: the choice of optimised recipes for concrete mixes, the way they are supplied onto the structures and working out the appropriate methods for compacting and curing fresh concrete. The concrete class required by the design was only that of BH15 as, according to the author of the design, concrete built into the head body was supposed to be a filler only. Before the optimisation of the recipes started, we had suggested changing the concrete class to BH20 taking into account the possibility for dynamic loads to occur and difficult realisation condition during the winter. The choice of the optimised recipes followed the weather conditions which are typical for that time of the year, short-term and long-term weather forecasts and the necessity to supply the concrete mix from a place 30 km away from the building site. The weather conditions and the big distance excluded the application of pre-heated concrete components such as the aggregate and water to the concrete mixes [1]. It was only possible to modify mix properties with chemical admixtures, accelerating the processes of binding and hardening. On the basis of lab tests, we arrived at the optimum stack of the aggregates used - gravel and sand -, and then five working recipes were developed, the application of which allowed carrying on work at the curing temperature of -7°C during the day and -15°C at night up to the temperature of 15°C day and night. Depending on the weather conditions, the type and the composition of the designed concrete mixes were established immediately before placing the concrete. In places difficult to access, the concrete was pumped and then compacted in the structure by rodding it with steel bars and hammering. In the remaining elements of the structure, the concrete was supplied in a dense-plastic consistence and then compacted with a poker vibrator. The concrete curing at negative temperatures was protected from a heat loss and downpour by being covered with thermally-insulating materials such as films, mats or canvas paulin. We tried to avoid accelerated curing of the concrete by heating it with steam or warm air due to a possibility of locally overheating the fresh concrete in the structure and the threat of cracking and crazing. The concrete, curing at a temperature higher than 5°C, was continually sprinkled with water for 21 days. While placing the concrete, we collected samples for strength tests. 15 cm cubes were cured on site and in the lab. Depending on what was needed, we tested the compression strength of the concrete after 6 ÷ 28 days. The concrete built into the structure attained the assumed parameters, corresponding to class B20.

The determination of fresh concrete strength was of special significance during the final phase of placing the concrete. Concrete curing under normal circumstances attains guaranteed strength after twenty eight days. In order to accelerate the repair work, it was necessary to earlier apply load to the structural element in which the strings which held the base of the support gate upper bearing were anchored. After the requisite strength tests and static-strength calculations had been made, a statement was made about allowing for lock head operation after six days of the date of finishing the concrete work [6], thereby reducing the duration of the refurbishment by at least fourteen days. This was possible owing to the appropriate admixtures which accelerated the concrete's attaining higher strengths.

After the concrete work had ended, the support gates and flow canals closures were started to be put up. Installed were the drives and power hydraulic elements. After the wiring had been laid in the cable canals and the control-signalling systems had been in place, the test run started, first without load and then with load. In parallel, finishing work was carried on: construction of slopes immediately adjacent to the head, installation of handrails and a water gauge, painting jobs and paving of the slopes immediately adjacent to the head. After successful tests of opening and closing the support gates and wedges in the flow canals, and after the new rubber seals had been proved tight, the upstream partition was cut, the repair closure of the head was disassembled and the lock was put in operation on the date planned. After a year of operation, the refurbished lock is working faultlessly.

4 Summary

In order to maintain navigability on the Oder Waterway, it is necessary to keep upgrading the other hydrotechnical objects, constructed over eighty years ago. The process of refurbishing the Ratowice Lock presented here is one of several upgrades presently being performed on the canalised Oder. The repair work done without having to shut down the navigational route is possible during the navigational break only, i.e. during the winter season, which is highly unfavourable for this kind of actions. An extensive programme of repair work might be completed in an efficient and timely way only through mutual cooperation between dedicated contractor companies, design and investment supervisors and scientific-research units.

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