ROYERS LOCK

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1 INTRODUCTION

The Royers Lock is one of the oldest locks in the Port of Antwerp, dating from 1907. It is the southernmost of five locks on the right bank of the port. Due to its excellent location, it almost directly links the Albert Canal – which is the most important inland waterway in Belgium in terms of traffic – with the tidal Scheldt river.

Built in 1907 and put into operation in 1908, the lock is 182.5 m long, 22 m wide and 13.41 m deep. Originally intended for maritime shipping, the lock was until recently mainly used for inland navigation. As a consequence of the economies of scale in maritime shipping, the lock became too small for most maritime vessels. But even for inland navigation, the lock has become rather small. For example, a convoy of four push-barges can't pass through the lock.

Being in operation for almost 115 years, the lock was outdated and required a lot of maintenance in order to be kept operational. The Royers Lock will now be renovated and upgraded, to be better adapted to the size and needs of current day inland navigation. The new dimensions will be 235 m long (inside the lock doors), 36 m wide and 13.41 m deep. The design of the new lock will also take into account climate resilience, as the new lock will be part of the Scheldt river basin flood defence system.

Figure 1: Existing situation vs. artist impression of the new lock complex (© ZJA architect of the Royers lock)

A movable bascule bridge will be built on both sides to allow vehicles and cyclists to pass easily over the lock. The design is based on the Kieldrecht lock and consists of two single rolling gates. The lock gates are moved by winches that are located behind the gate chambers in the machine buildings and that operate the gates by means of cables. The winches are powered by motors. The bridges are moved by hydraulic cylinders that are installed in the bridge basements.

To realise this, a dry construction pit is needed.

2 CHALLENGES FOR THE DESIGN OF THE CONSTRUCTION PIT

Research in several archives showed that the Royers lock has a comprehensive history between 1700 and today. First, there was the old river Vosseschijn on the location of the Royers lock. Later on, the Lefebvre dock was build. Afterwards the construction of the precursor of the Royers lock was started, which was situated closer to the river Scheldt than the current lock. However, flooding of the construction pits forced an early stop of the execution works. Finally, the existing lock was constructed around 1900. It was built with large steel caissons, filled with concrete that were sunk to the right level. These steel caissons are located at the three gate recesses and at the quay walls in the entrance canal.

This short summary of the history of the project location clarifies why the soil is quite disturbed and contains a lot of underground structures. An additional challenge for the design of the construction pit is the presence of (heritage) buildings in the neighbourhood. Some of these historical buildings have to be preserved in their present condition.

3 DESIGN ALTERNATIVES

The base design option was to create a dry construction pit to be able to demolish the existing lock and build the new lock without big influence on the existing ground water levels. Therefore a water retaining wall behind the existing lock walls in combination with two cofferdams (one at the river side and one at the dock side) was needed.

3.1 Design With Vertical Diaphragm Walls

The first design of the construction pit consists of vertical diaphragm walls. These walls have a retaining height varying between 14.8 m and 21.5 m (ground level at +7.00 mTAW, excavation level between –14.50 mTAW and -7.80 mTAW). The bottom of the walls is situated in the Boomse clay layer, so that the construction pit can be drained. Because of the large retaining height ground anchors and/or struts are needed at two levels. To limit execution risks, ground anchors are only provided above the ground water level (approximately 2 m below ground level). When using struts the large dimensions of the construction pit are an important restriction: at some locations it is not possible to have struts between two opposite walls because of the buckling length. In that case the only option is to realise the lock floor in several stages so that the middle part of the floor can be used as a reaction massive for the struts.

Taking into account the restrictions mentioned above, two solutions are found for the diaphragm walls. One possible solution consists of a diaphragm wall with thickness 1.5 m, ground anchors above the ground water level and struts to the middle part of the new realised lock floor. Another solution is increasing the passive resistance of the walls by grouting below the excavation level (approximately 7 m depth x 12 m width). In that case only the ground anchors are necessary and the struts can be left out.

In both solutions the verifications in ultimate limit state (geotechnical stability, structural calculation of the wall) are fulfilled, but the horizontal deformations of the wall are quite large. The horizontal and vertical deformations of the nearby ground level are also significant. As a result important damage can be expected for the (historical) buildings and the pumping station located close to the construction pit.

3.2 Design With Slopes

As an alternative the construction pit can be designed without vertical retaining walls but with slopes. Because of the disturbed underground a gentle slope of 10/4 must be used. For the watertightness a cement bentonite wall is needed at the borders of the construction pit. This cement bentonite wall has a thickness of 80 cm, a bottom level in the Boomse clay layer, and is only water retaining (not earth retaining).

3.3 Final Design

Both designs of the construction pit (with diaphragm walls or with slopes) have their advantages and disadvantages.

The design with slopes takes more open space, which is an important disadvantage in an urban environment like Antwerp. For that reason the implantation of the roads on site is already taken into account in the global layout of the construction pit. In the design with slopes some historical buildings are situated within the construction pit and can't be retained, which is another disadvantage.

The main disadvantage of the solution with diaphragm walls, in this case, is the higher cost price comparing with the slopes. Especially the cost of anchors, struts and/or grouting has a significant contribution in the total cost. Another disadvantage of the solution with diaphragm walls is the 'difficult' execution compared with a construction pit with slopes. As a result, more problems can be expected during execution.

Taking into account the arguments mentioned above, the design with slopes is chosen.

4 LOCK MASTER RESIDENCE

The lock master residence is a historical classified building, situated within the construction pit, in the area of the slopes. To preserve this building, a diaphragm wall will be constructed around it. In this way the lock master residence can stay as a 'tower' in the construction pit. The ground level between the building and the diaphragm wall is equal to the initial ground level, while the ground level outside the diaphragm wall equals the excavation level of the construction pit. On top of the diaphragm walls a concrete capping beam with anchors is provided. The anchors have a horizontal alignment and connect two opposite sides of the diaphragm walls to each other. In addition, the lock master residence is stabilised by jetgrouting to prevent vertical settlements.

5 INTEGRATED APPROACH IN ONE BIM-MODEL

Part of the design study was the creation of a fully integrated 3-D BIM model: the lock, as well as the bridges, electromechanical equipment and surrounding infrastructure were modeled. Very important was the evaluation of the design in various positions and conditions, as these are moving parts. All sub-models of steel, concrete, earthworks, mechanics and infrastructure were brought together into one coherent, coherent and qualitative design.

Applying a BIM model within infrastructure projects has numerous benefits:

- a better quality and more transparent cooperation between all parties
- the interfaces of the various disciplines are attuned to each other
- a clash-free design means less failure costs and a faster throughput time overall
- the extracts are one on one correct and reliable

Finally, this BIM model of the Royers lock can also be used as a basis for visualisations, a VR environment and digital safety walks. For a brief video how this is implemented for the Royers lock, click here: https://www.youtube.com/watch?v=sdWNks5rtjE.

Figure 2: example output of the BIM model (© SBE nv)

6 ROYERS LOCK AS A PART OF OOSTERWEEL

In 2015, the Flemish Government took a major decision on the most emblematic project from the Masterplan 2020, the closure of the Antwerp ring road (also called ‘Oosterweelverbinding’). A new crossing under the Scheldt river will be constructed, aimed at solving the huge road congestion problems in the Antwerp region. An important interchange (‘Oosterweelknoop’) of this road project and a tunnel (‘Kanaaltunnel’) are in the direct vicinity of the Royers Lock site.

Figure 3: Location of the Royers Lock and location of the interchange and tunnel (dotted line) (© Lantis)

As indicated in the figure above, the construction sites of the interchange and tunnel on the one hand and the lock on the other hand interfere with each other. The upper lock head and the tunnel tube will be linked. That is why it was decided to jointly tender the construction of the interchange ‘Oosterweelknoop’ and the renovation and upgrading of the Royers Lock. Having one contractor for both infrastructure projects should ensure that construction works on one project don’t affect or harm the other project or its construction site.

This decision is reflected in the practical arrangements for this project. The infrastructure manager for the ring road project, Lantis (official name: BAM NV van publiek recht), was assigned as the tendering authority for a tender consisting of two lots: 1) the interchange ‘Oosterweelknoop’ (on behalf of Lantis) and 2) the renovation and upgrading of Royers Lock (on behalf of Port of Antwerp). The main construction contract in relation to the renovation and upgrading of the Royers Lock was thus tendered by Lantis, with Port of Antwerp and the Flemish Department of Mobility and Public Works being involved in the evaluation process.

The preparatory works for the ‘Oosterweelknoop’ interchange have started in the summer of 2021.

Between May 2022 and August 2023, a cofferdam will be constructed near the location of the upper lock head of the new Royers Lock. This will have an impact on the lock project, as without this cofferdam the works on the building pit for Royers Lock can’t be finished. Apart from that, both projects run more or less in parallel, without too much interference. The constructions works on the ‘Oosterweelknoop’ interchange will run from 2023 until 2030, while construction works on this project of the Royers lock run from October 2021 until December 2027.

For the lot on the Royers Lock, Port of Antwerp is the client in the ongoing execution phase, being the owner of the construction site and future operator of the lock. The renovation of the Royers Lock is one of the top priorities in Port of Antwerp’s 10 year investment plan. In accordance with the modalities of the cooperation agreement signed on 21 April 2021, Port of Antwerp and the Flemish Government (Department of Mobility and Public Works) agreed that the latter would ensure inter alia technical management, safety coordination and site control during the construction of the project.

7 ROYERS PROJECT ON SITE – PLANNING

Due to an incident in February 2021, the lock was permanently taken out of service, causing hindrance for inland navigation. Waiting times for inland navigation seeking to enter the port of Antwerp or the Albert Canal also increased due to the closure of the Royers Lock.

Construction works on the new lock have started on 11 October 2021 and are expected to be finished by the end of 2027. The works can be divided in four main categories:

1. Preparatory works, related to the clearing of the construction site and permanent operation of the construction site during execution. This includes inter alia:
    a. Demolishing the existing lock, adjacent infrastructure and service buildings, removal of building rubble from the construction site. 75 % of all the building rubble will be transported by inland barge.
    b. Removing or rerouting cables and pipes on the construction site.
    c. Driving sheets piles with a total surface of 24,800 m² around the construction site.
    d. Permanently lowering the ground water level at the construction site at -15m TAW (TAW is the Belgian reference level), whereas the ground level on site is +7m TAW.

2. Ground works, related to the excavation and later filling of the construction pit. This also includes the construction of water-retaining cofferdams around the construction pit. It is estimated that more than 400,000 m³ of soil will have to be excavated for the construction pit and afterwards 435,000 m³ of soil will be needed to fill the construction site again. According to the latest planning most of the ground works will take place within the framework of this application. 75 % of all the transports related to the soil excavation or filling will happen by inland barge.

3. Concrete works. New waterborne infrastructure will be built, the main components being:
    a. the lock chamber, including culverts
    b. door chambers
    c. bridge cellars
    d. the mobile flood defence system

    The total amount of concrete needed in the global project is estimated at 152,250 m³, most of which will be processed within the framework of this application. 14,000 tonnes of reinforcing steel will be needed for the concrete works as well. Please note that sustainable concrete will be used for this task, resulting is much lower greenhouse gas emissions during the production of the concrete. The self-closing mobile flood defence system is an innovative solution in order to ensure climate resilience of the new infrastructure. It respects the flood protection norms of the Scheldt river basin. Flood protection at +9.25m TAW will be ensured, whereas the ground level on site is +7 m TAW.

4. Lock doors: the construction and installation of two new lock doors. The lock doors will be constructed elsewhere in Flanders. 1,800 tonnes of steel will be used for the construction of the two new lock doors. As the lock doors are floating constructions, they will be transported to the construction site over water.

By the end of December 2026, the major construction works on the waterborne infrastructure should be finished: door chambers, bridge cellars, lock chamber, lock doors and the mobile flood defence system. Works on the mechanics, electronics and hydraulics, as well as on the ancillary infrastructure continue after the end of this project. The new lock complex (the global project) will be in operation by the end of 2027, eliminating a capacity bottleneck for inland navigation.

SUMMARY

The Royers Lock is one of the oldest locks in the Port of Antwerp, dating from 1907. It is the southernmost of five locks on the right bank of the port. Due to its excellent location, it almost directly links the Albert Canal – which is the most important inland waterway in Belgium in terms of traffic – with the tidal Scheldt river.

Built in 1907 and put into operation in 1908, the lock is 182.5 m long, 22 m wide and 13.41 m deep. Originally intended for maritime shipping, the lock was until recently mainly used for inland navigation. As a consequence of the economies of scale in maritime shipping, the lock became too small for most maritime vessels. But even for inland navigation, the lock has become rather small. For example, a convoy of four push-barges can't pass through the lock.

Being in operation for almost 115 years, the lock was outdated and required a lot of maintenance in order to be kept operational. The Royers Lock will now be renovated and upgraded, to be better adapted to the size and needs of current day inland navigation. The new dimensions will be 235 m long (inside the lock doors), 36 m wide and 13.41 m deep. The design of the new lock will also take into account climate resilience, as the new lock will be part of the Scheldt river basin flood defence system.

A movable bascule bridge will be built on both sides to allow vehicles and cyclists to pass easily over the lock. The design is based on the Kieldrecht lock and consists of two single rolling gates. The lock gates are moved by winches that are located behind the gate chambers in the machine buildings and that operate the gates by means of cables. The winches are powered by motors. The bridges are moved by hydraulic cylinders that are installed in the bridge basements.

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RESUME

L'écluse Royers est l'une des plus anciennes écluses du port d'Anvers, datant de 1907. Elle est la plus méridionale des cinq écluses situées sur la rive droite du port. Grâce à son excellent emplacement, elle relie presque directement le canal Albert – qui est la plus importante voie navigable intérieure de Belgique en termes de trafic – à l'Escaut à marée.

Construite en 1907 et mise en service en 1908, l'écluse mesure 182,5 m de long, 22 m de large et 13,41 m de profondeur. Destinée à l'origine à la navigation maritime, l'écluse était jusqu'à récemment principalement utilisée pour la navigation intérieure. En raison des économies d'échelle réalisées dans la navigation maritime, l'écluse est devenue trop petite pour la plupart des navires maritimes. Mais même pour la navigation intérieure, l'écluse est devenue plutôt petite. Par exemple, un convoi de quatre péniches ne peut pas passer par l'écluse.

En service depuis près de 115 ans, l'écluse était obsolète et nécessitait beaucoup d'entretien pour rester opérationnelle. L'écluse de Royers va maintenant être rénovée et modernisée, afin d'être mieux adaptée à la taille et aux besoins de la navigation intérieure actuelle. Les nouvelles dimensions seront de 235 m de long (à l'intérieur des portes de l'écluse), 36 m de large et 13,41 m de profondeur. La conception de la nouvelle écluse tiendra également compte de la résilience climatique, puisque la nouvelle écluse fera partie du système de défense contre les inondations du bassin de l'Escaut.

Un pont basculant mobile sera construit des deux côtés pour permettre aux véhicules et aux cyclistes de passer facilement au-dessus de l'écluse. La conception est basée sur l'écluse de Kieldrecht et consiste en deux portes roulantes simples. Les portes de l'écluse sont actionnées par des treuils qui se trouvent derrière les chambres des portes dans les bâtiments des machines et qui actionnent les portes au moyen de câbles. Les treuils sont actionnés par des moteurs. Les ponts sont déplacés par des cylindres hydrauliques installés dans les sous-sols des ponts.

Pour réaliser cela, une fosse de construction sèche est nécessaire.

ZUSAMMENFASSUNG

Die Royers-Schleuse ist eine der ältesten Schleusen im Hafen von Antwerpen und stammt aus dem Jahr 1907. Sie ist die südlichste von fünf Schleusen am rechten Ufer des Hafens. Aufgrund ihrer hervorragenden Lage verbindet sie den Albert-Kanal – die wichtigste Binnenwasserstraße Belgiens – fast direkt mit der gezeitenabhängigen Schelde.

Die 1907 erbaute und 1908 in Betrieb genommene Schleuse ist 182,5 m lang, 22 m breit und 13,41 m tief. Ursprünglich für die Seeschifffahrt gedacht, wurde die Schleuse bis vor kurzem hauptsächlich für die Binnenschifffahrt genutzt. Als Folge der Größenvorteile in der Seeschifffahrt wurde die Schleuse für die meisten Seeschiffe zu klein. Aber auch für die Binnenschifffahrt ist die Schleuse eher klein geworden. So kann beispielsweise ein Konvoi von vier Schubleichtern die Schleuse nicht passieren.

Da die Schleuse seit fast 115 Jahren in Betrieb ist, war sie veraltet und erforderte einen hohen Wartungsaufwand, um betriebsbereit zu bleiben. Die Royers-Schleuse soll nun renoviert und modernisiert werden, um sie besser an die Größe und die Bedürfnisse der heutigen Binnenschifffahrt anzupassen. Die neuen Abmessungen werden 235 m Länge (innerhalb der Schleusentüren), 36 m Breite und 13,41 m Tiefe betragen. Bei der Konstruktion der neuen Schleuse wird auch die Klimaresistenz berücksichtigt, da die neue Schleuse Teil des Hochwasserschutzsystems des Scheldebeckens sein wird.

Auf beiden Seiten wird eine bewegliche Klappbrücke gebaut, damit Fahrzeuge und Radfahrer die Schleuse problemlos passieren können. Die Konstruktion basiert auf der Schleuse von Kieldrecht und besteht aus zwei einzelnen Rolltoren. Die Schleusentore werden von Winden bewegt, die sich hinter den Torkammern in den Maschinenhallen befinden und die Tore mit Hilfe von Seilen betätigen. Die Winden werden durch Motoren angetrieben. Die Brücken werden mit Hydraulikzylindern bewegt, die in den Brückenkellern installiert sind.

Hierfür ist eine Trockenbaugrube erforderlich.

RESUMEN

La esclusa de Royers es una de las más antiguas del puerto de Amberes, ya que data de 1907. Es la más meridional de las cinco esclusas de la orilla derecha del puerto. Gracias a su excelente ubicación, enlaza casi directamente el Canal de Alberto – que es la vía fluvial más importante de Bélgica en términos de tráfico – con el río Escalda, que tiene una gran cantidad de mareas.

Construida en 1907 y puesta en funcionamiento en 1908, la esclusa tiene 182,5 m de longitud, 22 m de ancho y 13,41 m de profundidad. Originalmente destinada a la navegación marítima, la esclusa se utilizaba hasta hace poco principalmente para la navegación interior. Como consecuencia de las economías de escala en la navegación marítima, la esclusa se quedó pequeña para la mayoría de los buques marítimos. Pero incluso para la navegación interior, la esclusa se ha quedado pequeña. Por ejemplo, un convoy de cuatro barcazas no puede pasar por la esclusa.

Al estar en funcionamiento durante casi 115 años, la esclusa estaba anticuada y requería mucho mantenimiento para mantenerse operativa. Ahora, la esclusa de Royers será renovada y modernizada para que se adapte mejor a las dimensiones y necesidades de la navegación interior actual. Las nuevas dimensiones serán de 235 m de largo (dentro de las puertas de la esclusa), 36 m de ancho y 13,41 m de profundidad. El diseño de la nueva esclusa también tendrá en cuenta la resistencia al clima, ya que la nueva esclusa formará parte del sistema de defensa contra inundaciones de la cuenca del Escalda.

Se construirá un puente basculante móvil a ambos lados para que los vehículos y los ciclistas puedan pasar fácilmente por la esclusa. El diseño se basa en la esclusa de Kieldrecht y consta de dos compuertas rodantes simples. Las compuertas de la esclusa se mueven mediante cabrestantes que

están situados detrás de las cámaras de las compuertas en los edificios de máquinas y que accionan las compuertas mediante cables. Los cabrestantes son accionados por motores. Los puentes se mueven mediante cilindros hidráulicos instalados en los sótanos de los puentes.

Para ello se necesita un foso de construcción en seco.