Reducing flood risk

‘Room for the River’

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In order to maintain the Dutch flood defense in times of climate change, the national ‘Room for the River’ program has been initiated. More than 30 projects have been defined by the Dutch government in order to contribute to the task to create a safer place to live, work, and recreate. The Nijmegen location in the river Waal was the main bottleneck in the Dutch river system, and therefore a key project in the ‘Room for the River’ program. The ultimate aim for the project was to dig a secondary channel on the river in order to lower the water level and increase the river’s capacity; therefore reducing the flood risk. This was accompanied by the relocation of an existing dike 350 meters further inland and building three new bridges and a new quay. Due to the construction of the secondary channel, the existing area transformed into an island in the center of the river that is set to host a mix of new living, recreational, cultural, and natural spaces.

The winning contract strategy
A single bypass for the highway was the key qualification for contractor combination i-Lent (Dura Vermeer and Ploegam) to win the contract in 2012. The client, the government and authorities of Nijmegen, wanted minimal impact on the city’s traffic during the building phase. Despite it being a relatively large secondary project, the single bypass (approx. 320.000 cubic meters of soil and a steel construction of 120 tonnes) also meant a cost-saving measure by eliminating the need to have multiple solutions for different phases of the work.

In addition to this, presenting a strong design that met the client’s specification for a striking part of the city that made a statement was also key to winning the contract. Whilst other competitors offered lower cost solutions, i-Lent’s balance between delivering a project on budget and on time, meeting the client’s demands for aesthetics of the structures and landscaping seemed to be the better fit.

Multidisciplinary design team
Having a great architectural team and a strong position on BIM engineering not only enabled i-Lent to offer an appealing design but also a clever, workable design in terms of construction. The contractor winning the contract was committed to subcontracting the preselected architect of each of the three bridges crossing the secondary channel.

A total of four architectural and seven engineering firms were subcontracted during the design and constructing phase. Fugro was responsible for the interface between the spatial design of the river park (coordinated by HNS)

and bridges (three architects) and the geotechnical and hydraulic design challenges (several engineering firms). Typically for geotechnical design issues, the best solutions are invisible once construction is finished. Nevertheless, a well thought out subsoil layout is indispensable in order to guarantee the functionality and usability of the constructions and facilities.

Figure 1: Extended Waalbrug

Building the bridges: the challenges

Two new bridges and an extension of an existing bridge were part of the project. The bridges connect the new island to the northern part of Nijmegen (the town of Lent). Furthermore, in the former floodplain, the new secondary channel crosses the existing railroad bridge, which had to be provided with fortified piers.

The Waalbrug bridge (1936), a steel arch bridge across the river Waal, had to be extended (*Figure 1*) in order to cross the secondary channel. The architectural design of Zwart Jansma did not provide in a second arch. With respect to the 'Old lady of Nijmegen', the lower side of the new bridge and piers is accented.

The new bridge extension is constructed at the exact location of the former ramp. This 15-meter-high soil construction created a certain amount of compaction of the subsoil due to 80 years of loading. In order to build the foundations of the piers, this soil ramp had to be excavated, resulting in an expansion of the compressed soil layers. Recompression, due to reloading during the pouring of the concrete, was a severe risk for the quality of the concrete. Ten-stage compression-unloading-recompression tests were carried out. The PLAXIS calculations, performed by Fugro, proved that the replacements fell within the critical margins of the concrete construction.

Figure 2: 'Lentloper' bridge

Between the 'Waalbrug' and the existing railroad bridge, a new bridge to the new island is constructed. This 'Lentloper' bridge is intended for walking, cycling, and car traffic (*Figure 2)*. This Ney-Poulissen bridge design appears to be intended for staring dreamily into the water or enjoying the sunset, instead of the fastest connection between two points. The walking level is situated significantly below the narrow carriageway and includes two shortcuts to cross under the bridge.

Next, architects made the design for the gracefully swinging 'Zaligebrug' footpath and cycling bridge in the river park (*Figure 3)*. The bridge enables a tour around the river park, provided the water level being normal. With rising water levels, the stepping stones make an alternative access to the bridge, but during design water levels, the complete bridge is allowed to flood. Furthermore, the 'Zaligebrug' will occasionally be used as a supply access and for emergency vehicles during events on the island.

The existing railroad bridge crosses the current floodplain. Due to the excavation of the secondary channel, the existing piers had to be fortified. Although this was not part of the contract, the influence of the adapted piers to bottom scouring had to be assessed. A complication was the oblique position of the piers with respect to the currents in the channel.

Figure 3: Zaligebrug

Underneath the railroad bridge, a new dike including a seepage wall had to be constructed. The boundary condition for the construction was not to influence the railroad timetable. An extensive monitoring system of displacement and vibration sensors enabled Fugro to quantify the performance limits for the construction.

A fifth bridge forms the crossing 'Oversteek' between the city of Nijmegen and the north shore. This bridge was not part of the contract either, but obviously had to be integrated in the design of the river park. The building activities of this bridge were merely parallel to the excavation of the secondary channel and coordination between both contractors was therefore crucial for a satisfying result.

The river park: functionality and pleasure in one design

The primary purpose of the urban river park as designed by HNS landscape architects was to result in a water level reduction of 34 centimeters during a 1/1250 flood event. From an extensive soil investigation, some typical

Figure 4: Reinforced piers railroad bridge

geotechnical problems of the area were determined. Due to the high water-permeability of the subsoil, inhabitants of the nearby town of Lent would face severe seepage problems from the secondary channel during high water periods. As a preventive measure, a 20-meter-long cement-bentonite wall was installed to block the seepage flow under the dike and quay.

Besides an icon with recreational function, the 1,600-meter-long new quay includes a partially hidden eight-meter-high L-wall which also performs as a water retaining structure. Therefore, the design of the connecting structure between the seepage construction and the L-wall demanded special attention. The challenge was not solely technical, but merely required interface management between the different disciplines.

Since every construction and element above and below the surface was designed three-dimensionally and combined in a Building Information Model (BIM), regular clash control revealed the problems in an early stage of the multidisciplinary design process. This method proved to be efficient as well as cost-reducing in the overall planning.

In the western part of the river park, nature and water prevail. This area is suitable for walking and recreating along the shores of the river Waal and the secondary channel. Inhabitants of Nijmegen come out here for fresh air or hang out on the beaches of the river Waal. On the event site, appealing cultural activities can be organized. The central part of the island 'Veur-Lent' exudes an urban atmosphere. The area connects the Nijmegen old town with the new residential areas on the north shore 'De Waalsprong'. On the island itself, new houses and urban development is foreseen. The water of the secondary channel is excellent for rowing and other water sports. East of the Waalbrug, the peninsula and channel are more forested. Equipped with boots strolling along the shores, it is excellent for bird watching from the dike or fishing along the Waal shores: this is the place to explore the river, flora, and fauna, just outside the town borders.

Figure 5: Construction of the new dike

Figure 6: i-Lent formwork for the extended 'Waalbrug'

The new quay 'Lentse Warande' on the north shore of the channel stretches from the extended 'Waalbrug' to the railroad bridge and is part of the new dike. The design consists of an inclined paved slope, disappearing into the water. Along the quay, one can enjoy cycling, walking, and relaxing on one of the terraces or along the boat jetties. At the upstream entrance of the secondary channel, a dam was constructed in order to manage the distribution of the water. At different levels of the dam, six inlets provide a constant inlet of fresh water for the channel during low river discharges. At a certain water level, the dam will overflow utilizing full flow capacity of the channel during river floods.

A successful Room for the River project

Highlighting the excellence of i-Lent's work in Nijmegen, the 'Verlengde Waalbrug' extended bridge won the 2015 Concrete Award in the bridges and viaducts category. Equally as significant, the Room for the Waal project as a whole was recognized for its collaborative success by winning the Dutch Bouwpluim award in 2015.

Whilst the market is growing in the Netherlands, with more large and interesting projects coming to market, it is still tough and companies are having to offer smart solutions in order to win contracts. ◄

Figures:
Header, 1-6 *Fugro*