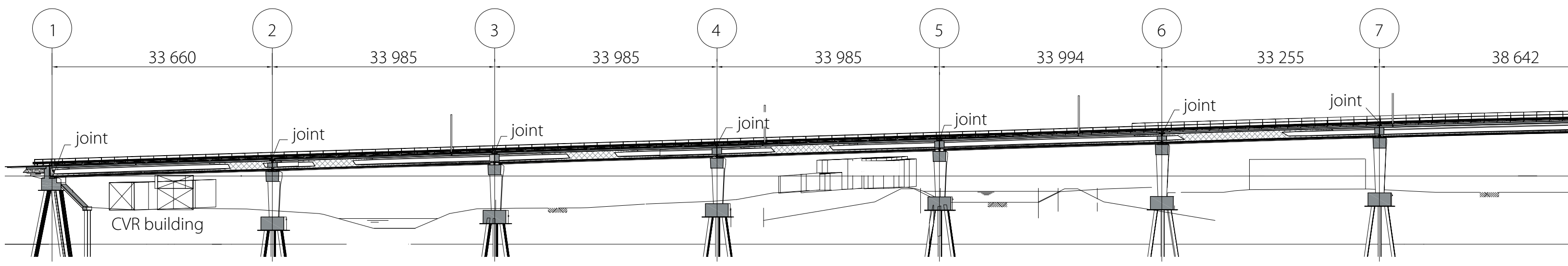
New Gouwe bridge beside aqueduct will ease traffic on A12

Amalia Bridge Waddinxveen

Where the A12 and A20 motorways merge, before passing under the Gouwe aqueduct, both the flow and safety of road traffic become critical. In order to expand the road network around Gouda, under the name 'A12 Parallel Structure', the province has constructed two new roads: the Extra Gouwe Crossing and the Moordrecht Bow. Within the Extra Gouwe Crossing, the 'Amalia Bridge', designated also as 'ancillary structure KG', showed to be highly challenging; both structurally and in terms of fitting into the existing situation.



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1 Amalia Bridge over the Gouwe, Waddinxveen
2 Top view on the Amalia Bridge
3 Longitudinal cross-section

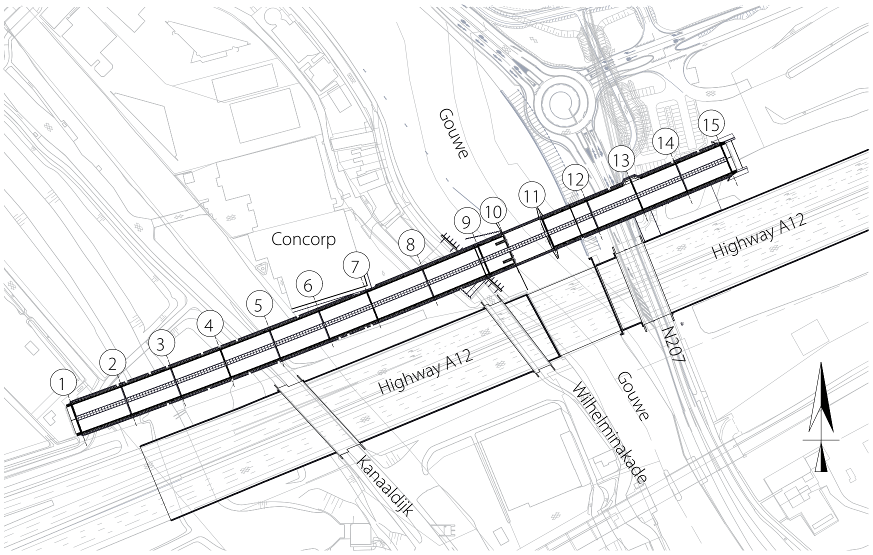
The road crosses the river Gouwe just north of the Gouwe aqueduct by means of a new drawbridge (photo 1). Apart from the Gouwe, this structure also crosses local roads (from west to east): Kanaaldijk (N484), Wilhelminakade and N207. The bridge consists of a movable section (the leaf, a steel structure), and concrete approach ramps to the east and west of the bridge (fig. 2 and 3).

Situation

Because structure KG lies immediately beside the existing Gouwe aqueduct, this object formed the de facto working boundary on the south side. With this in mind, and in order to minimize the impact of construction activity on the existing aqueduct, it was preferable to place the bridge as far as possible from the A12 (to the north). It was essential to take into account not only the visible parts of the Gouwe aqueduct, but also the subsurface grouted anchors. However, another barrier was formed by several commercial properties on the northern side. One of these properties is a confectionery manufacturer (Concorp), whose production depends on sensitive weighing equipment. Together with the aqueduct, these factors constrained the position of the bridge in the north-south direction. Likewise, the position of the western abutment was restricted by the presence of another existing object: a road-traffic control centre. This building is equipped with ICT equipment for control of traffic systems, and therefore has a critical function in traffic management. To avoid jeopardizing this building and its function, the western bridge abutment has been positioned at a sufficient distance. Fortunately, the location of the eastern abutment was not subjected to any positional constraints. What did determine the position was the maximum extent for the approach embankment in order to maintain the necessary landscape quality in the vicinity of the structure.

Design of deck structure

The total length of structure KG from eastern to western abutment is approximately 450 m. The bridge is divided into an



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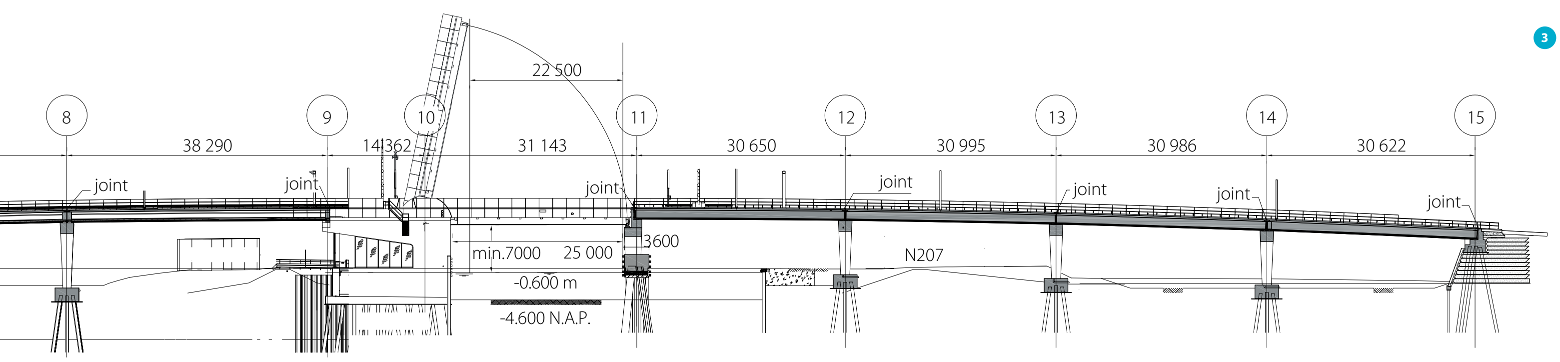
eastern approach ramp (124 m), the bascule pit and steel leaf (together 45.5 m) and the western approach ramp (280 m, all lengths approximate). The required 2 × 2 lanes, in combination with a median of about 3 m width (ensuing from the landscape plan), and bevelled fibre reinforced plastic edge elements (ensuing from the visual quality plan) result in a total deck structure width of approximately 21.6 m (fig. 4).

Construction method

To construct the approach ramps quickly and with minimal disruption to the surroundings, the deck structure was built using precast concrete beams. The first beams were placed in position from the side of the abutments, while the remaining sections were hoisted into position by cranes from each finished section of the deck. This working method meant that there were almost no interruptions to traffic on the underlying road network. Moreover, this also avoided the need for temporary structures to create a stable foundation for the cranes on the soft Gouda ground. Nevertheless, this did make it necessary to dimension both the deck and its substructure for the crane load.



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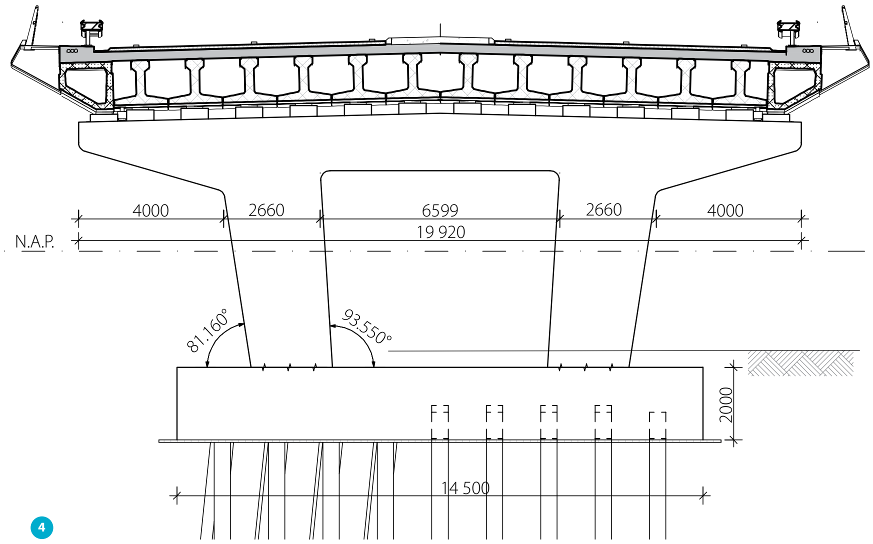
4 Cross section
5 The land piers are designed as double T-pillars on a footing which is founded on precast concrete piles
6 T-heads that hold the rods to the ends of the deck supporting beams



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Structure

The span dimensions are based on several preconditions. First of all, the beams could not be too heavy, due to the chosen construction method. Furthermore, the positional constraints arising from the current situation (i.e. traffic control building, Kanaaldijk, the necessary distance from the Concorp site, Wilhelminakade, intersection with the Gouwe and the N207) also played a significant role. Finally, it was desirable to choose a beam length that could be repeated as often as possible. For the eastern approach ramp this resulted in four spans of 31 m, and for the western approach ramp, six spans of 34 m and two spans of 38 m (approximate lengths). The transition from span to span is formed by non-rigid expansion joints and rubber expansion joints in a steel claw. The spans are constructed from precast concrete I-beams with tapered box girders at the sides.

Land piers

At rows 2 to 8 and 12 to 14 (fig. 2 and 3), the deck structure rests on land piers. These piers are designed as double T-pillars on a footing which is founded on precast concrete piles (photo 5).

6

This enabled the construction of a foundation structure that fits into the existing situation (grouted anchors of the Gouwe aqueduct) but is still wide enough to support the deck structure. The land piers are made of concrete with strength class C55/67.
To achieve sufficient load-bearing capacity in the soft Gouda subsoils, it was necessary to drive the precast concrete piles approximately 10 m into the firm sand layer. This resulted in a pile toe depth of 20 to 25 m below sea level. Piling and vibration analyses carried out beforehand indicated that pile-driving was feasible, and would not lead to unacceptable risks for existing objects, particularly the traffic control building and Concorp. The subsequent pile-driving work proceeded smoothly, and all piles were placed at the correct depth in the correct manner.
A challenge for the pier design was the fact that the outer box girders, each up to 38 m in length, had to be placed on a 4 m long cantilever on top of the pillars. As described earlier, it was also necessary to consider crane loads together with the hoisting weight of the precast beams. As a consequence, the upper reinforcement in the deck support beams incorporates several layers of Ø40 mm rods. These rods are mechanically anchored to the ends of the deck supporting beams by means of 'T-heads' (photo 6) in order to avoid complicated reinforcement detailing in that small space at the end of the construction.

River pier

Row 11 is the position of the support pier for the moving leaf of the drawbridge. This pier stands in the river Gouwe. The geometric and structural design of this pier is similar to that of the land piers. There is one major difference: this river pier has to be able to withstand a collision from water-borne traffic. As a result of the magnitude of this load, prefab concrete piles could not be used, so steel tubular piles were used for this foundation. To optimize the tubular pile dimensions, a more detailed analysis of the navigation channel and nautical traffic was carried out resulting in a reduction of the collision loads, which meant that

8

8 Bascule pit: the beam at row 9 is modelled schematically as a rib that is part of the 2D element, which itself is the roof of the bascule pit

smaller tubular pile dimensions would be sufficiently robust (photo 7).

Final phase of bascule pit modelling

The bascule pit (photo 8) was structurally analysed using a 3D schematic model in SCIA Engineer. In this model, the beam at row 9 is modelled schematically as a rib that is part of the 2D element, which itself is the roof of the bascule pit. This beam spans approximately 15 m, and bears the weight of the precast deck above. Because the forces acting in this beam are dependent on the stiffness of the corner columns that support it, the analysis was performed both with the cracked and uncracked columns.

Construction phase

The preceding paragraph concerns the final phase. However, the roof was not yet in position during the construction phase.

7

7 An analysis of the navigation channel and nautical traffic led to a reduction of the collision loads and smaller tubular pile dimensions

Obviously this had to wait until the steel leaf and ballast box were in place. Because the beam was still not finished at that point in time, and, therefore it lacked sufficient strength to support the prefabricated deck beams, a temporary support structure was built below the beam, which was later removed once the roof was ready. The same SCIA Engineer model was used for this phase as for the final phase, except without the roof. In addition to the models for the purpose of the overall structural analysis, a separate model was also made to determine the forces in the consoles. These consoles are cantilevered from the concrete wall, and are subject to dynamic forces from the moving parts. A push-pull rod transfers forces from the leaf to these consoles via the panama wheels: large pinion-driven gears that open and close the steel leaf of the drawbridge. A complicating factor in the structural analysis is the varying angles at which the forces act on the concrete consoles, depending on the position of the steel leaf. Another is the fact that the forces also switch from tensile (when the bridge is raised) to compressive (when the bridge is lowered).

On December 23 2016, the bridge was opened , providing the alternative route for traffic. As a result, one can choose such a route so that the traffic jam is avoided and with this, the problem of major bottleneck is solved. Although it was a challenge to fit the Amalia Bridge in the existing situation, Heijmans has managed to engineer and successfully build the bridge on time. ☒

PROJECT DETAILS

project Bridge over the Gouwe river (part of A12 Parallel Structure)
client Province of South-Holland
contractor Heijmans Infra
architect Zwarts and Jansma
structural design Heijmans Infra
first pile bridge KG 12 June 2015
bridge KG opening end of 2016