The assembly and replacement of the Weesperbridge

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Summary

In The Netherlands the long closing of main roads and major waterways are unacceptable due to economic reasons. So swapping of the old Weesperbridge for the new one , must be completed within eight hours. Also de transportation is a problem of the new bridge in a densely populated country as The Netherlands. This is challenge that the design engineers have to deal with while searching for a method to swap the two bridges in a short period of time.
To realize the transport the new bridge must be transported in two sections. The first section is the arch and the second is the bridge deck. The engineers must make sure that the structures remain stable during all steps of the construction.
For the installation within one night, the strength and stability must be checked in all steps of construction. This results in the following measures:

- To reduce stresses in the arch and the maingirder temporary columns were placed between the to.s;
- The pendants needed added supported to prevent buckling;
- The flange of the maingirder is strengthened around the temporary bearings to reduce stresses;
- Around the temporary bearing by the girder web, stiffeners were added to prevent plate buckling.

Keywords: steel, temporary structures, stability, heavy lifting, transportation and installation

1 Introduction

The Amsterdam-Rhine Canal is one of the main waterways in The Netherlands. The canal is an important connection between the port of Amsterdam and the Ruhr in Germany, making it one of the busiest canals in the world. The decision to build the canal was made in 1931 but due to the economic crisis of the thirties and the Second World War, the canal was not completed until 1952. Since the Amsterdam - Rhine canal passes through the busiest part of Holland there are numerous roads and therefore dozens of arch bridges that traverse it.

Several of these bridges date back to the early days of the canal and are therefore exceed 80 years of age. The Department of Transportation and the administrator of the canal, put a request for tender out for the major strengthening and maintenance of 8 steel arch bridges, to guarantee a residual lifespan of 30 years. One of the most important requirements for this project was to minimize the disruption to automobile traffic and shipping during the realisation. For this reason, the contractor decided to replace old bridges with 4 new ones, instead of performing lengthy and risky maintenance and reinforcement activities. By building the new bridges off-site , the old bridges can be replaced within one weekend, so to minimize the disruption to automobile, and shipping traffic.

2 The replacement of the Weesperbrug

The Weesperbridge is located east of Amsterdam and dates back to 1937. The Weesperbridge is one of the eight bridges in the project which will be replaced by the Contractor.

The new Weesperbridge was built in the production hall of the Contractor in Gorinchem, located on the Merwede river. The advantage of this location is that the bridge can be transported via the rivers of Holland. The rivers the Merwede, the Rhine and the Amsterdam-Rhine Canal were used to transport the bridge sections to the project location. This paper describes the whole process from engineering to installation and the engineering challenges.

The chosen construction method of exchanging the old bridge for the new bridge will minimize the impact for shipping and the environment on the Amsterdam-Rhine Canal.

Figure 1.The old Weesperbridge

3 Boundary conditions

The limited space in the production hall and the limited bridge clearances of the Amsterdam-Rhine Canal determined the prefabrication- and transportation method. For the transportation to the assembly-site it was necessary that the bridge be divided into an arch and a bridge deck section. Before the on-site assembly it was pertinent that the bridge be fully assembled outside the production hall to ensure a proper fit. After the successful trail assembly, the bridge was then ready for transport.

The pendants are first fully integrated in the bridge and then later divided and marked for reconnection on site. After the trailassembly the bridge was placed on a pontoon with use of SPMT’s. The support spans where fastened on the main span while on the pontoon. Therefore it was necessary to use a temporary structure to support these parts during construction. This structure consisted of a hinged connection to the upper side of the deck and a butt connection on the bottom flange of the main girder.

4 Production, transportation and reconnection

Because of the limited height of other bridges across the canal, the arch and its pendants must be separated and transported separately from the rest of the bridge. As mentioned the bridge was completely assembled built in de production hall of the contractor to ensure a proper fit during placement. With this the arch and pendants will be installed with the help of temporary bolt connections. After the load-out on the factory both parts were transported separately to the temporary construction site in an arm of the Amsterdam-Rhine Canal. Were on the wharf two 600 tons cranes lifted the arch from the barge and placed on the steel deck, which is lying on a pontoon. First the arch needed to be connected to the steel deck then the pendants were connected one by one.

4.1 Transport

The arch and the bridge deck where transported separately to the construction site due to the limited passing height of multiple bridges. . The deck was floated to the building site “Nigtevecht” on three pontoons.. The arch has a deadweight of 125 tons, and was hoisted with a floating shearleg onto the barge. Because of the relatively low weight of the arch section the ship had to be ballasted with 2100 tons of iron ore. In addition to the iron ore the barge itself was ballasted with

Figure 3. Assembly Arch to deck

1,320 liters of water to increase the draft of the barge. Otherwise barge and the ship would not be able to pass under the bridges along the Amsterdam-Rhine Canal. Once the arch section arrived in Nigtevecht the ballast water was discharged from the barge to lower the draft before entering the construction site in the Harbor.

4.2 Assembly of the sections

At the construction site the arch was hoisted onto the deck (figure 2), the arch-deck connection and pendants will be connected. To reduce waves on the canal during this process active navigation guidance was necessary to reduce the speed of passing ships.

The hoisting points on the arch are designed so that the arch curves 10 to 15 cm inwards (figure 3

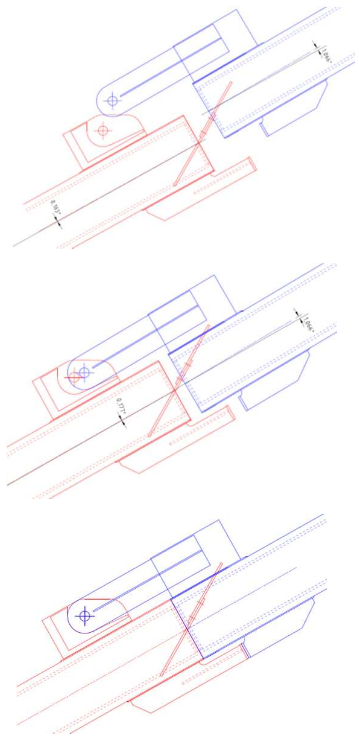

Figure 2. Three Phases of assembly

and 4) on both sides during placement. In this way the receiving structure of the bridge, the deck, can fixate the arch and camber it back to its original position.

After the arch and the deck are fitted and welded together the pendants must be connected. While on the pontoon the bridge deck is still cambered. The bridge deck will be cambered during the coupling of the pendants and then brought back to its original position. The engineer developed an assemblyscript to connect the pendants in the correct order.

The connecting of the pendants to each other must be carried out in increments of 5 cm per pendant to control the stresses in the arch structure.

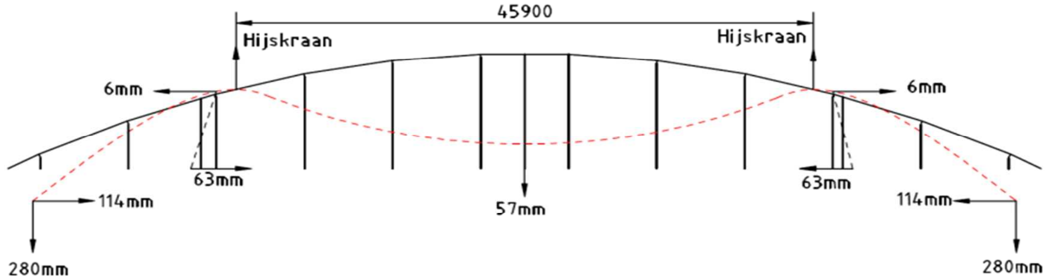

Figure 4.The deformation of the arch during assembly

5 Production, transportation and reconnection

After the complete bridge is assembled at the temporary construction site, the bridge will be transported to its final location on a single pontoon. At that moment the bridge is supported by two points under de main girder. These points are not the final load bearing points, Each step in this exceptional situation have been analyzed. This results in the following measures:

- The installation of temporary columns between the arch and the main girders, to reduce stresses;
- The pendants must be supported to prevent buckling;
- The flange of the maingirder must be strengthened near the temporary bearings to reduce stresses;
- In the girder web around the temporary bearing, stiffeners are added to prevent plate buckling.

5.1 Temporary Columns and stabilization of the pendants

During the transportation of the bridge from the assembly site to its final location the bridge is supported by four points within the main span. This creates a lot of internal forces to the bridge structure. The arc is designed as a compression arch. During assembly the arch receives tensile forces. The main girder receives compression forces and bending moments (figure 5). The pendants are narrow, round tubes which can only withstand a minimum compression force. Without additional measures the pendants will buckle and the bridge will become unstable. To prevent this, two temporary columns are placed between the deck and the arch directly above the temporary supports. These columns bring the active transport forces to the arch and keeps the structure stable.

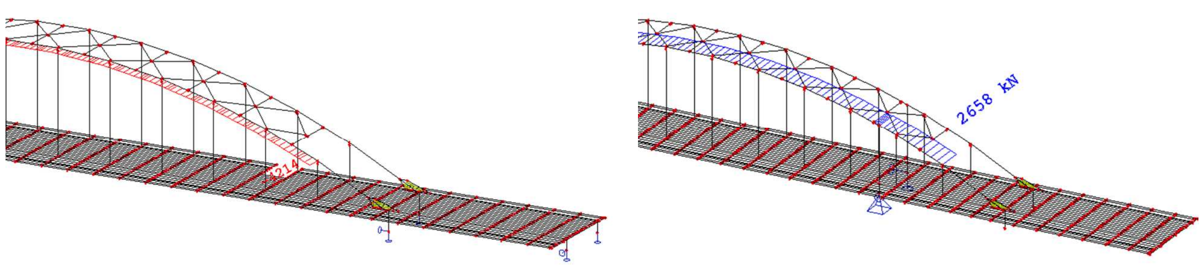

Figure 5. Compression in the Arch in the regular situation and tension during the installation.

In spite of the temporary columns there are still compression forces in the pendants. The buckling strength of these columns are very low and must be temporarily stiffened. For this purpose I-beams are mounted along each pendant. These give additional stability, so the Euler buckling force increases and buckling of the pendants does not occurs.

5.2 Strengthening of the flange in the main girder to prevent plate buckling of the girder web

In addition to the stiffening of the pendants and the temporary columns, there are also additional measures needed in the main girder. As mentioned the main beam has compression forces and bending moments as a result of the temporary supporting during transportation (figure 7 and 8). The bottom flange receives much higher tension stresses than in a regular situation. Therefore, the bottom flange of the main girder is designed thicker to prevent buckling off the bottom flange during installation. To prevent plate-buckling of the web plate a local stiffener is fitted on the web plate (Figure 6).

Figure 6. Stiffeners to prevent plate buckling of the girder web

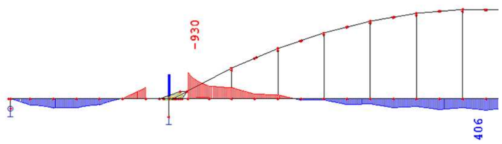

Figure 7. Regular bending moments

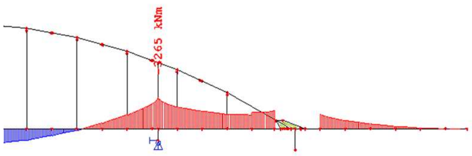

Figure 8. Bending moments during the installation.

6 The installation

After all the engineering- and preparation work was completed, the bridge could be transported by pontoon to its final location. For this the local government would only allow the channel to be obstructed for a maximum of 8 hours. Four hours to remove the old bridge, a 2 hour break so traffic can pass (ships). The remaining four hours were then used to place the new bridge. During installation the pontoon is positioned between the piers and the bridge was placed with an accuracy of 5 cm onto a temporary structure of jacks. With these jacks the bridge was positioned onto its final location (Figure 9).

Figure 9. Installation during the night

Figure 10. Removing temporary structures the day after

After the bridge was placed on its final position the channel was reopened for shipping. When the bridge was placed on its final bearings all of the previously described measures were removed and the bridge was opened for automotive traffic. (Figure 10).

7 Conclusions

In the Netherlands long closing of main roads and waterways are due to economic reasons unacceptable. . This requires construction methods that enable fast building so that bridges can be placed within a minimum disturbance to the road and waterway. This leads to challenges for constructors and engineers. The required installation method requires a lot of preparation. Manufacturers were responsible for: the stabilization of the structure during all building phases, and controlling of the force distribution in de structure and the determination of the most efficient method for building and installation of bridge.

8 Acknowledgement

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