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HEAVYLIFTING OPERATIONS FOR THE ASSEMBLY OF THE ARCH OF BRIDGE REPLACEMENT

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One of the main requirements for the Walterdale Bridge Replacement in Edmonton was to minimize the impact on the river during the construction. This was a big challenge, as the use of ordinary construction methods such as falseworks and cranes was almost impossible. Furthermore, the river was not navigable. Consequently, all water equipment used, such us barges, had to be modularized, land transported and assembled directly on site, limiting the capacity. Then, it was decided to split the construction of the arch in different stages, performing several special heavylifting activities. Firstly, a partial arch (the central part), weighing 1,000 metric ton was manufactured on a riverbank. After that, it was skidded and loaded-out onto two modular barges, which moved the segment to the area between the abutments. By means of two towers specifically assembled, which included four strand jacks, the arch was then partially lifted and connected to additional sections of the arch, creating a new 1,800 T and 146-m long arch. Following this, the new arch was also lifted to its final position, in a similar way. This paper describes all the special heavylifting operations and the equipment used to assemble the arch of the bridge, facing with severe weather conditions, such as temperatures down to -20ºC and a river partially frozen.

Keywords: Lifting, Strand jack, Skidding, Skidshoe, Modular barge, Load-out, Construction equipment, Walterdale.

1 BACKGROUND

The current Walterdale Bridge has stood for more than 100 years, crossing the North Saskatchewan River in Edmonton, Canada. Having reached the end of its service life, it needs to be replaced (City of Edmonton 2017). As a consequence, it was decided to build a new one to the East, the works starting in 2013.

The structure designed consists of an arch bridge, spanning the river with 206 m and being 56 m high. It is not a tied-arch bridge, but the steel arch (actually two arches connected transversally) is directly fixed to thrust blocks on both riverbanks. The road deck just hangs below the arch, whereas the pedestrian deck crosses the river laterally to the arch, supported by inclined hangers.

The construction methodology completely split the arch from the decks. The arch (scope of this paper) needed to be firstly installed and, after that, the decks had to be manufactured at the South riverbank and then placed in their final location.

The activities during the construction were strongly required to minimize the impact on the river. It made it almost impossible to use ordinary construction methodologies, such falseworks and cranes. In addition, due to the fact that the river is not navigable, ordinary pontoons could not be used as they could not reach the site sailing through the river. Therefore, in case of using any piece of water equipment, it had to be modular in order to be land transported to the site and then assembled directly on the river. The problem was the limited capacity of this kind of equipment. The bottom line, the construction of the arch was considered a significant challenge to cope with.

2 PROPOSED METHODOLOGY TO BUILD THE ARCH

After analyzing several options, the construction of the 206-m long arch was split in three different stages. The central section was decided to be completely manufactured on the river bank, some meters far from the longitudinal axis of the future bridge, and then moved along the river to the final location. The maximum length of this segment was limited by the capacity of the modular barges, which was additionally reduced due to the fact that they would not support the arch distributed along their entire deck, but locally in the center. Besides, the reduced draft of the river increased the limitation of the weight of the arch that could be moved.

The central segment of the arch was finally decided to be 86 m long, weighing 1,000 metric ton. Meanwhile, the rest of the lateral sections of the arch had to be manufactured in the river banks, on temporary supports, vertically aligned with their final location. Then, the connection between the central arch and the starting segments would be achieved working with two lifting operations. See Figure 1.

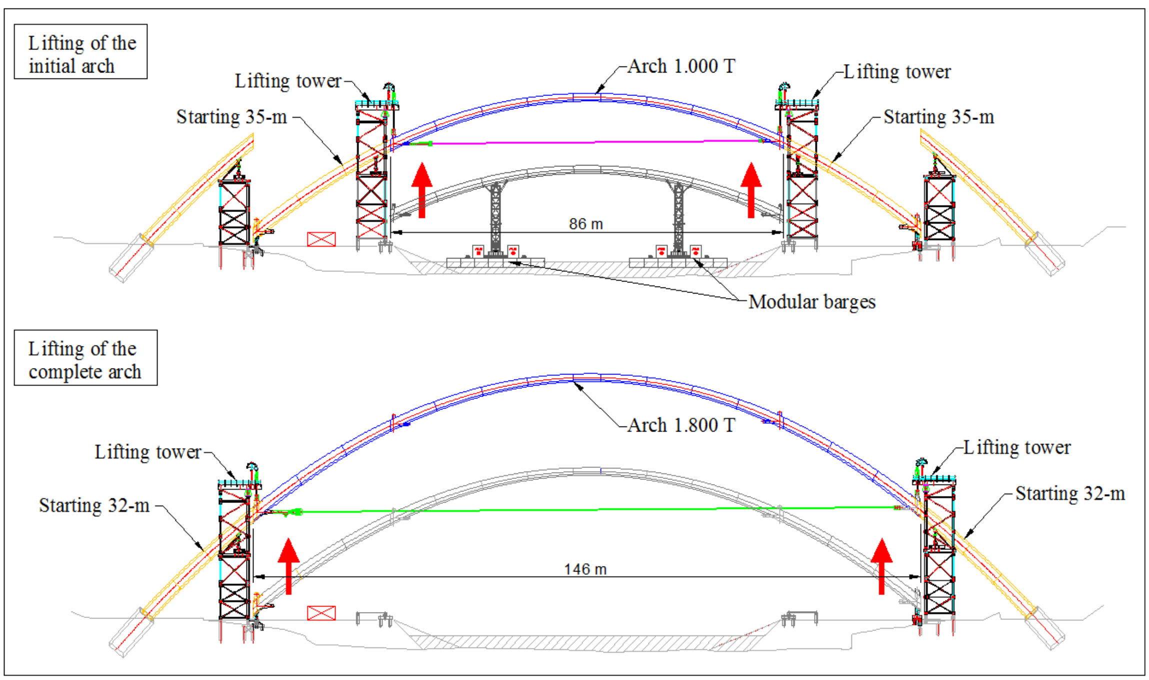

Figure 1. Sketch of the liftings for the methodology adopted.

Summarizing, the activities to be carried out for the assembly of the entire arch were:

1. Construction of the thrust blocks. Including the first starting segments of the arch, 32-m long, laying on temporary supports.

2. Preassembly of the following 35-m segments, separately, laying on temporary supports.
3. The rest of the steel arch, central segment, is completely manufactured on a riverbank, spanning 86 m and weighing 1,000 metric ton.
4. The central arch is loaded-out onto two modular barges in the river putting in service a skidding system.
5. The pontoons locate the arch aligned with the longitudinal axis of the future bridge.
6. By using auxiliary steel towers including synchronized strand jacks, the central arch is lifted and connected to the 35-m starting segments. It generates a new arch, 1,800 T weight and 146-m long.
7. With the help of other auxiliary steel towers including synchronized strand jacks, the complete arch is lifted and connected to the starting segments of the thrust blocks.

The following sections explain the special heavylifting maneuvers that were required to put the arch in place once having been manufactured, that is to say, activities 4 to 7.

3 ASSEMBLY OF THE ARCH

Once the central arch had been manufactured on the Southern riverbank, the heavylifting maneuvers explained below were carried out. The steel segment was 86-m long and 45-m high, weighing 1,000 metric tons. (Saenz 2016). It comprised two arches joined together by means of transversal steel ribs. See Figure 2.

Figure 2. Central arch (1,000 T) being manufactured on temporary supports.

3.1 Skidding and Load-out

Prior to the maneuver, two vertical trussed portal frames were fixed to the arch, called elephants. Additionally, a bow-string system was installed at the bottom of the two arches. It included two strand jacks 500 T capacity each (Saenz 2016), one per arch. Each jack connected the bottom extremes of the arches with 48 strands, 0.6-inch diameter each. The system would allow opening and closing the arch, controlling the deflection and preventing from overstressing, when the multiple temporary manufacturing supports were removed and the arch was simply supported.

After that, two pair of skidshoes were installed below the front and rear extremes of the arch. A skidshoe consists of a steel housing with a stainless-steel plate at the bottom surface. It also includes a vertical jack, where the element to be moved is supported, and a horizontal push-pull jack at the bottom. By acting on this jack, the skidshoe is able to slide along a skidtrack line, moving the element supported. The skidtrack includes PTFE pads to reduce the friction load.

With the pontoons already located on the river, the maneuver started. Acting on the vertical jacks of the four skidshoes, the central arch was gradually released from the temporary supports. In the same time, with the strand jacks of the bow string system, the geometry of the arch was controlled. After that, the arch was just simply supported by the pair of skidshoes and it started being skidded along the skidtracks.

Once the arch had reached the end of the skidtracks, the load-out was carried out (see Figure 2). The arch needed to be located onto two modular pontoons. It had to be supported through the two elephants, one per barge. For that purpose, a defined sequence of load transfers and change of positions of the skidshoes was followed. Meanwhile, the elevation of the barges was controlled and adjusted by using an electronically controlled ballasting system.

Figure 2. Skidding and load-out of the 1,000 T arch.

3.2 Navigation

Once the arch was supported by the two modular barges, the structure was moved towards the longitudinal axis of the future bridge. The pontoons, being 36.6 m long and 21.3 m wide (Saenz 2016), were accurately displaced putting in service eight winches: two 20 T and two 10 T capacity winches per barge. They had to be connected to different fixed points onshore during the navigation, depending on the stage. See Figure 3.

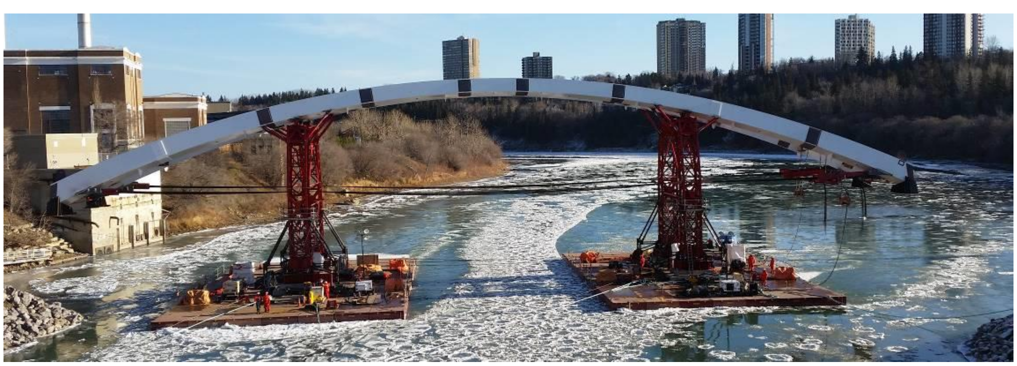

Figure 3. Navigation of the 1,000 T arch with two modular barges and eight winches.

3.3 First Lifting

The next activity consisted of lifting 15.5 m the 1,000 T arch, so as to join it with the 35-m starting segments (see Figure 1). For this purpose, two 30-m high steel towers were installed onshore, one per riverbank. Each tower included two beams in cantilever at the top, where two 500 T capacity strand jacks, one per beam, were installed. The total synchronized hydraulic system used then provided a lifting capacity up to 2,000 T, electronically controlled and operated. They were connected to four padeyes welded *ad-hoc* at the bottom part of the arch.

After five hours, with temperatures down to -20ºC (Saenz 2016), the arch reached the required elevation. After that, it was connected to the starting segments with a bolted joint. During lifting, the load on the four strand jacks was permanently controlled, preventing from overstressing of any diagonal which would dangerously twist the arch. The required horizontal adjustments were possible thanks to the acting on the bow-string system installed. It had the ability to open and close the arch as it was necessary, keeping inside the allowed parameters. See Figure 4.

Figure 4. Lifting 15.5 m of the 1,000 T arch by means of four strand jacks.

3.4 Second Lifting

The already lifted structure together with the starting segments generated a new 1,800 T arch, 146 m long and 70 m high. The final activity consisting of a 20.5-m high lifting, in order to connect the arch with the four starting segments already built in the thrust blocks (see Figure 1). For this last activity, the equipment employed was the same as the one used for the first lifting, except:

- The lifting towers were installed 30 m behind the first ones. They were wider, adapting to the shape of the new arch to lift.
- The lifting strand jacks installed were 850 T capacities, instead of 500 T. The total hydraulic system being able to lift up to 3,400 T.
- The bow-string system included two strand jacks 850 T each, instead of 500 T.

After five hours, and following the same methodology as in the first lifting, the arched reached the required elevation. Following that, it was welded to the starting segments, closing the structure. After that, the bow-string system was released and disassembled, finalizing the construction of the entire arch of the bridge. See Figures 5 and 6.

Figure 5. Lifting 20.5 m of the 1,800 T arch by means of four strand jacks.

Figure 6. Arch of the bridge completed.

4 CONCLUSION

The paper has described the cutting-edge equipment used and heavylifting operations carried out for the accurate and safe assembly of an arch bridge in adverse conditions.

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