CONSTRUCTION OF THE ARCH OF THE TAMINA BRIDGE

R. Meichtry, R. Kühne

Meichtry & Widmer AG, Zürich, SWITZERLAND.

e-mails: rmeichtry@meichtry-widmer.ch, rkuehne@meichtry-widmer.ch

SUMMARY

The construction of arch bridges has been a big challenge for skilled engineers from ancient times up to now. In the past most arches had been built on conventional timber scaffolds. Depending on the topographical and geotechnical situation (deep gorges, rivers, etc.) the construction of the scaffold had been in many cases very difficult, costly and time consuming. As for other structures the introduction of high-strength concrete and high-tensile steel has led to the development of new, more economical construction techniques for arch bridges. In the past years a considerable number of major concrete arch bridges have been built using the suspended cantilever construction method which is nowadays widely known.

Keywords: *Suspended cantilever method, alternative design.*

1. BRIDGE OVER TAMINA GORGE

The new open spandrel arch bridge across the Tamina Gorge, between Pfäfers and Valens in Eastern Switzerland, is currently under construction. Upon its completion, the Tamina Bridge will be one of Europe's largest arch bridges, spanning across the about 200 m deep Tamina Gorge. The total construction time for the bridge, including building of access roads, is expected to take about four years and will be finished in autumn 2016. In spring 2015, the construction of the arch was completed. The bridge will have a total length of 417 m. The asymmetric arch with a span of 260 m and a rise of around 35 m had been constructed step-by-step from both river banks by using the suspended cantilever method.

The cross section of the arch is variable in both directions. The width varies between 9.0 to 5.0 m, the height from 4.0 to 2.0 m. In the lower parts, the arch is constructed as a box girder, close to the peak the cross section is fully made of concrete. The thickness of the outer webs varies from 1.0 m at the abutment to 0.9 m. The thickness of the top- and bottom slab varies from 0.85 m to 0.55 m.

Transverse diaphragms are provided at the base of the radial spandrel columns in order to introduce the local forces into the webs. The deck structure is supported by 5 radially inclined columns spaced at 50.0 m. The deck is constructed as a precast box girder. The box girder is, similar to the peak of the arch, 5.0 m wide. The deck's total width is 9.5 m.

Fig. 1. *View from Northwest (on the side of Valens) – arch under construction.*

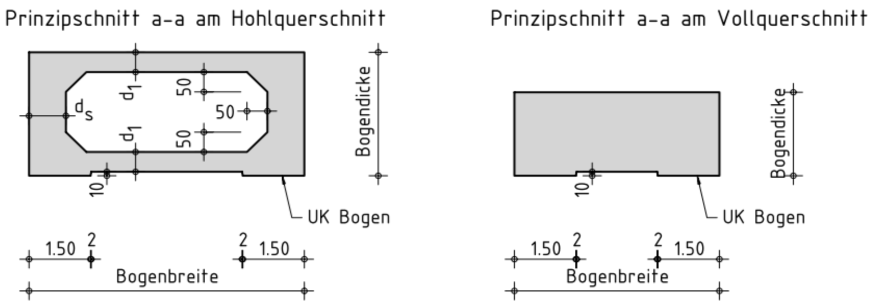

Fig. 2. *Cross-section of the arch (Leonhard, Andrä und Partner).*

2. CONSTRUCTION PROCEDURE

The arch was constructed step-by-step, from both river banks simultaneously in sections of 5.0 m using temporary stay and backstay cables. The cables used were BBR-VT monostrands (cross-section 150 mm2) with an ultimate tensile strength (u.t.s) of 1860 N/mm2. The number of strands per stay cable varies between 7 and 24 and for the backstays between 11 and 19. The cable carrying capacity is 5000 kN (2406) for the stay cables and 3750 kN (1806) for the backstay cables. The maximum allowable tensile stress during all construction stages was 0.55 u.t.s. For weather protection, the strands were PE-coated. The total of 55 arch segments was carried by 31 pairs of temporary stay cables and 24 pairs of backstays. For the construction of the arch of Tamina Bridge, 180 t of temporary cables were necessary.

However, before starting with the arch construction, both the permanent arch foundations as well as the temporary foundations for anchoring the backstay cables had to be completed. After some initial difficulties an erection schedule of one segment per week for each side could be established.

Fig. 3. *View from Southwest (on the side of Valens).*

In order to safely transfer the backstay cables forces to the underlying rock, 96 ground anchors of type CONA-avt L12 were used (ultimate force 2232 kN per anchor, total length of over 2'000 m). The load transfer from the backstay cables to the ground anchors was achieved by using welded steel transfer beams.

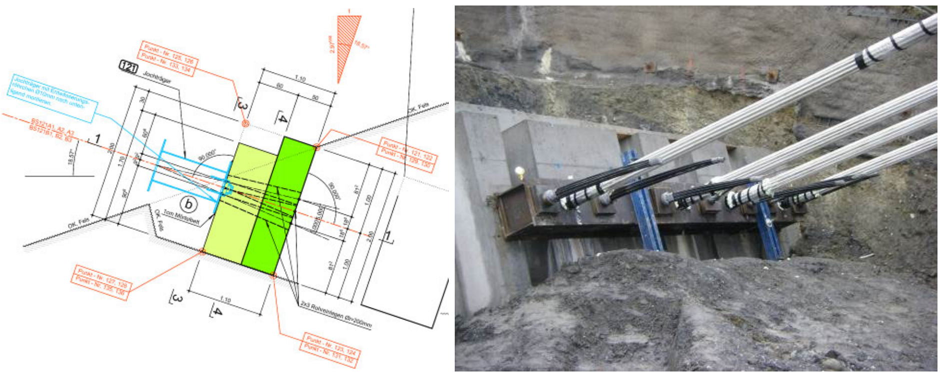

Fig. 4. *Foundation of backstay cables.*

The construction of the arch started immediately after completing the installation and assembly of the form carriers. The form carriers could be used not only for casting the 1st element but for all others including the closing pour.

Due to topographic constraints and the arches asymmetric geometry, the arch was supported by pylons with 3 levels on the side of Valens (73 m, 480 t) and 4 levels on the side of Pfäfers (109 m, 750 t). The pylons were located above the arch springings and served temporarily to transfer the vertical components of the stay and backstay cables into the foundation. To transfer loads between stay cables, pylon and backstays, beams with a weight from 30 to 48 t were installed on every level of the pylons (around every 25 m). Up to a maximum of 7 pairs of stay cables and 5 pairs of backstays are installed per transfer beam. The aim was to have the horizontal components of stay and backstay cables mostly in equilibrium, to minimize the bending moments in the pylons. Unfortunately, keeping this equilibrium is in conflict with a simple tension sequence which would be desirable for a rapid construction progress. In this case, the decision was made to build stronger pylons and to keep the simple tension sequence. Eventually, before finishing the arch, an axial force of 4600 t reached the foundation on the Pfäfers side.

Fig. 5. *Pylon and transfer beam.*

The details for stressing the cables were indicated in the stressing programme. To minimize bending moments for each stressing operation both the stay and corresponding backstay cables were tensioned nearly simultaneously (in small steps). Forces in the cables and deformations of pylon and arch were continuously monitored by geodetic survey, confirming the positions of pylon and arch after finishing the stressing process.

Generally the erection of an element includes the following phases:

- Advancing the form carrier
- Placing the form carrier
- Installation of a new cable if intended
- Stressing of cables
- Casting of element

The superstructure will be constructed on traditional formwork. According to the current schedule, the bridge is expected to open for traffic in 2017.

Involved parties:

- Owner: Tiefbauamt Kanton St. Gallen
- Main contractor: STRABAG – Erni – Meisterbau
- Structual design: Leonhard, Andrä und Partner, Stuttgart
- Alternative design: Meichtry & Widmer, Zurich
- Formwork: Lehrgerüst GmbH, Meiningen
- Cables: KB Vorspann-Technik, Salzburg