Repair of the Historic Arched Bridge in Naila with CarboBeton

1. Introduction

From the time of its construction around the year 1910 until 1973, the arched bridge over the Selbitz valley served as a viaduct of the former railway track Naila-Schwarzenbach am Wald. Due to its location, it is also called the entrance gate to Naila. After left unused for almost 40 years, in the course of the cycling track Naila-Schwarzenbach am Wald, the impressive structure should be repaired from scratch and then used for another purpose.

The arched bridge consists of 3 main arches with clear spans of 15.00 meters with a pitch of 9.30 meters each and a small arch at the western end. In the peak, the wall thickness is between 60 cm and in the abutment, approximately 140 cm. The arches themselves are made from non-reinforced concrete, whose structure and resistance varies considerably due to the manufacturing conditions. In the result of the examinations of the drill cores and the tests of the compressive strength with the rebound hammer, a minimum compressive strength according to the strength group C 16/20 applicable today can be assumed. Increased contents of sulphate, which can result to a formation of ettringite respectively a drift of the sulphate in the repair of the concrete, were not detected in the chemical analysis of the drill core samples. The chloride content was also far below the permissible limit values.

2. Damages prior to the repair and their causes

In the course of the object-related analysis of the damage, the construction was inspected ready to hand. In addition, at the arches, 4 drill cores have additionally been taken for the testing of the concrete composition, the compressive strength, the e-module and the adhesive pull strength. Moreover, 2 drill cores for the examination of the pillars and their foundation as well as 1 drill core for the testing of the sealing and of the sloping concrete have been taken from the building construction. Above and beyond, grout samples were performed and the old track ballast has been tested for its pollution level. For a uniform evaluation, the damages have been recorded with the software program 'SIB-Bauwerke' and in addition documented in drawings.

With an overall score on the condition of 2.9, pursuant to the RI-EBW-PRÜF, the building construction was still in a sufficiently good condition. The stability of some components was impaired but this posed no impairment to the stability of the building construction as a whole. Besides, the adherence to safety rules so as to prevent accidents and the durability of the building construction were impaired, for its conservation, a repair within a short period of time was necessary.

All arches were characterized by numerous transversal and networklike cracks as well as clearly visible concrete section joints with distinct sinterings, which were deposited on large areas of the concrete surface.

Ilustration 01: Damage existing at the bottom side of the arches. Photo: Ammar Al-Jamous

Obviously, the formation of cracks was caused by the concrete technology of this time, by the composition of the concrete with an imbalanced mixing ration of the additives as well as the shift-wise introduction by hand without the respective tools for the compacting of the concrete. The result was a defective respectively disturbed concrete microstructure with the formation of a network or separating cracks caused by an early shrinkage and/or plastic settlements as well as cavities and defects of up to 1.5 cm in diameter. Here and there clearly visible gravel pockets were an additional indication for the varying quality of the concrete. As another reason for the distinct cracks, moisture penetrations with sinterings in combination with the effects of frosts have to be mentioned. Over the long standing time of 100 years, this resulted in an increase in the formation of cracks and spallings in places.

3. Repair concept:
The arched bridge will be essentially preserved and the damage to the concrete and the masonwork will be eliminated by means of suitable repair measures.
After a time-consuming examination of possible alternatives, due to the obvious advantages it has been decided to repair the superstructure at the bottom side with TUDALIT textile reinforced concrete. The bottom side of the superstructure (arches) should be repaired with two layers of carbon reinforcement embedded in fine concrete.

Illustration 02: Fixing of the carbon reinforcement in the fine concrete.
Photo: Ammar Al-Jamous

The reinforcement works have been performed according to the rules of the general building supervision approval with the approval number Z-31.10-182. For the reinforcement, the following materials have been used:

- Coated carbon reinforcement TUDALIT-BZT2-V.FRAAS (TohoTenax Carbon),

- Fine concrete TF10 PAGEL/TUDALIT FINE CONCRETE

The application of the fine concrete was carried out with the MAWO-PAGEL dense phase wet spraying application method.

The reinforcement began with the application of the first layers of fine concrete onto the prepared old concrete. Into this, the first textile reinforcement layer was introduced. Subsequently, the freshly introduced textile reinforcement was once again covered with a layer of fine concrete.

As the reinforcement works had to be interrupted due to the sizes of the areas to be reinforced, the last layer of fine concrete was roughened up with the stroke of a broom prior to the exceeding of the application life. The next day the spraying of a new layer of fine concrete was performed into which the second layer of the carbon reinforcement was built in. Then, a last fine concrete layer served as a covering of the second reinforcement layer. The layer built-up of the carbon concrete was roughly 20 mm in total.

The repair works with the PAGEL/TUDALIT fine concrete lasted for roughly 3 weeks including the interruptions. The company carrying out the works was the Laumer Bautechnik GmbH, Leipzig branch. The planner of the structural work was the engineering office K+U-Plan Ingenieurgemeinschaft, Knijnenburg und Kuthan from Wunsiedel. The planning of the textile concrete reinforcement and the external monitoring was assumed by the company CarboCon GmbH, Dresden.

Illustration 03: View on the finished bridge. Photo: Ammar Al-Jamous

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