Repair and strengthening of the CANOT Bridge in Besançon, France, for the crossing of the First Tramway Line

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Summary

The Canot Bridge is a triple arch bridge, rebuilt in 1949, after WWII. It is located in the center of the city of Besançon, over the Doubs River. The span of each of the three main arches is 27,40 m and the rise is 4,31 m. In the cross section, the structure consists in 3 arches, having a width of 2,20 m and a height varying from 0,80 at the crown to 1,00 m at the spring. The particular point is that the arches are made of concrete with no reinforcement. The deck is supported by the arches by means of diaphragms. Initially, the bridge was supporting one lane in each direction. In 1979, the bridge has been widened with an additional concrete cantilever structure, allowing two lanes in each direction. Two lanes will be sacrificed to allow the bridge to carry 2 tramway lines.
The object of the study was to check the structure under these new load cases. One of the issues is that neither any information about the building phases nor the bearing conditions of the arches on the piers was available for the study. This article will present the results and the decided strengthening works. Works on site have started in August 2012 and will last until April 2013.

Keywords: arch bridge; non reinforced concrete; strengthening; composite materials.

Fig. 1: General view of the bridge

1. Context of the operation

The operation of strengthening and maintenance of the Canot Bridge takes place in the global project of the building of the first tramway line of the “Grand Besançon” which will be inaugurated in 2014.

The first subject of the mission was to produce a detailed model of the bridge. One of the key points was the correct modeling of the bearing conditions.

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The study was mainly based on a comparison of the current and future strengths generated by the dead and live-loads, including the tramway loads.

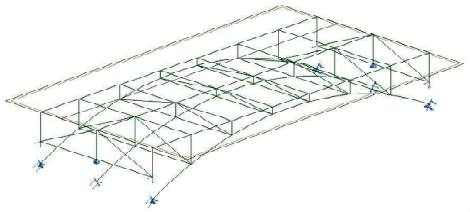

Fig. 2: Isometric view of the 3D model

Arch bearing condition: We noticed that no rebar is crossing the joint, so a non-linear bearing condition was introduced in the model. This NL means to transmit compression but no tension.

Results:
The pressure line under the worst combination (temperature -40°C; location of the live-loads at ¼ of the span) goes out of the central-third. In that case, cracks could appear in the section and if no redistribution of the strength is possible, the structure could fail. After a discussion with the actors involved in the operation, and according to the very good state of the arches, the age of the structure and the fact that the new loads will be less aggressive than the current ones, which occurred the last 60 years, it has been decided not to strengthen the arches.

After that, the specifications of the tendering for the works of strengthening and partial demolition/reconstruction have been provided.

2. Strengthening of the bridge

The detailed calculation of the different parts of the bridge showed a lack of resistance for several parts: the slab, the longitudinal and transverse beams and the diaphragms. The solution chosen is a strengthening using composite glued materials because, according to the time schedule, the different phases of works, the easiness of implementation and the cost, it seemed to be the best solution. In addition, some diaphragms are strengthened to increase their shear strength.

3. Works on site

The works on site have begun in August 2012, by mounting the scaffoldings and platforms under the structure and the demolition of the superstructures. The first strengthening using composite materials have been realized. The company that won the tender proposed an alternative solution in order to avoid the casting of asphalt. It proposed the use of fiber reinforced concrete instead of the asphalt.

4. Conclusion

The apprehension and calculation of non-reinforced concrete is relatively complex, due to the fact that the regulations are relatively silent on that subject (the regulations are written for reinforced concrete) and that the calculation programs that allow nonlinear behavior are not written to compute a fragile-type behavior. Fortunately, in the present case, the new loads on the bridge will not lead to a situation worse than the present situation, avoiding a general strengthening of the arches, that would have had the disadvantage of hiding all the surfaces and therefore complicate the inspections of the bridge in the future, especially to check and follow the evolution of potential small cracks.