APPLICATION OF FIBRE CONCRETE FOR THE BRIDGE OVER LOCHKOV VALLEY IN PRAGUE

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Abstract

The large continuous frame bridge on the motorway ring around Prague has composite steel and concrete box superstructure. The reinforced concrete deck slab has polypropylene micro-fibers admixture and taper-threaded splicing system for main longitudinal reinforcing bars in order to minimize cracking development. Short description of the structure, technology and construction of the whole bridge, detailed technique of the fibre concrete, from preparation and testing up to concreting process. Results of technical inspections and measuring during construction and after the first year from concreting the last section..

Keywords: frame-bridge, composite superstructure, fibre concrete, polypropylene microfibers, taper-threaded splicing system, cracks development.

1. Introduction

Bridge across the Lochkov Valley, of the total length of 425.30 m, is situated on the South-west segment of the Prague Ring Road and crosses the deep valley at a height of 63 m. The whole bridge is in a plan curvature with radius of 747.5 m, in longitudinal slope of 2.4% and transverse slope of 4.0%. The bridge is formed by a strutted frame of span of 157.103 m, with the five spans deck of 70.00 + 79.85+ 99.30 + 93.85 + 80.50 m and variable width from 33.600 up to 35.425 m and the depth in the bridge axis 4.800 m. Fig. 1.

The deck is a composite one cell box girder with large overhangs, of a steel trough with inclined webs and top flanges and of fibre concrete deck. Two external and one internal stringer are supported by external and internal inclined pipe struts situated at distance from 3,088 do 4,500 m. The stringers are transversely tied together by steel GEWI- bars. The top webs' and stringers' flanges are provided by shear studs. The compressed flanges have thickness up to 165 mm, above supports, where the required thickness is up to 190 mm, the tension flanges are assembled from two plates. Fig. 2.

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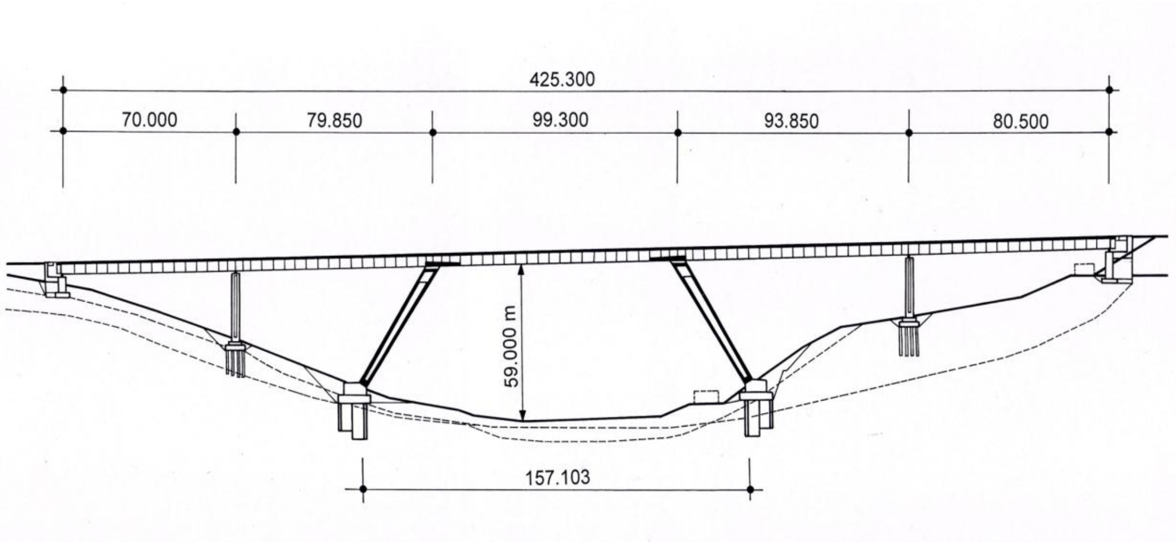

Fig. 1: Bridge elevation

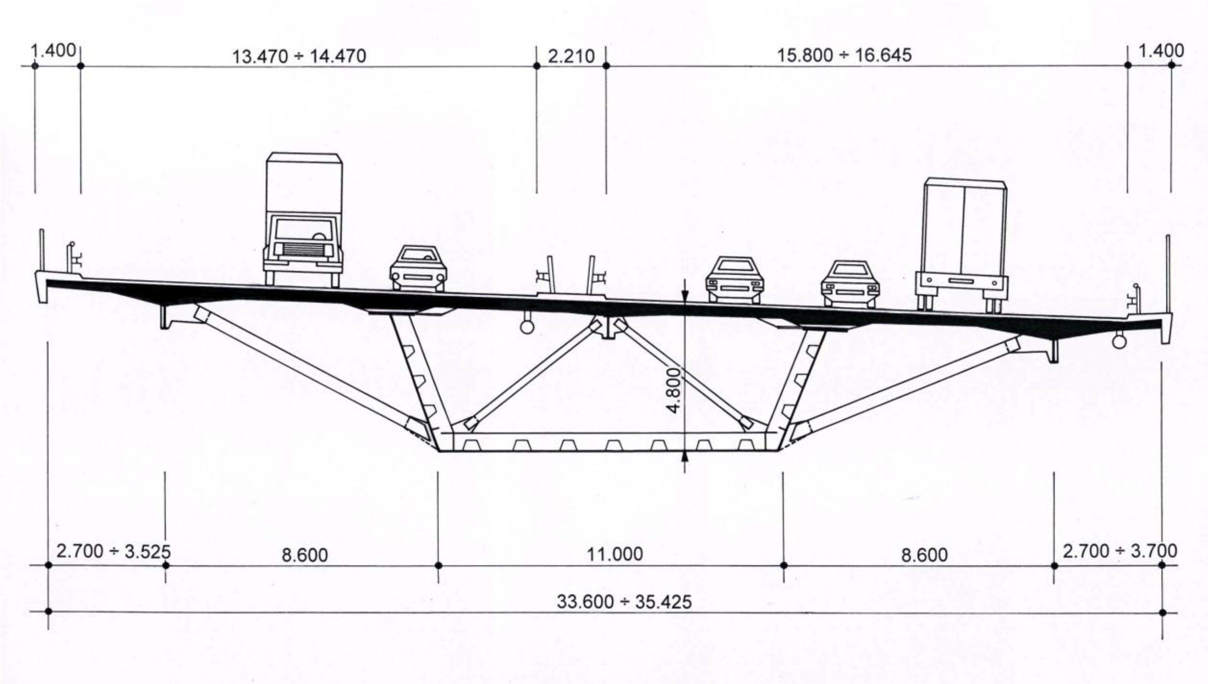

Fig. 2: Cross section of the superstructure

Fig. 3: Bottom view of bridge

The substructure and diaphragms transferring stresses from steel members into inclined piers are from concrete. Vertical piers are formed by two columns of the solid rectangular cross section 4.00 x 2.80 m that are mutually tied by transversally prestressed link beams. The inclined piers of the length 52.50 m are formed by couples of two struts of the box sections of the constant width of 4.050 m and variable depth from 3.400 to 5.300 m. The longitudinal reinforcing bars situated close to the top and bottom surface of the struts are coupled. The forces from the struts are transferred into the footings by strengthened solid sections. At the head are struts mutually connected by pier capital, connected again with the superstructure by means of prestressing and reinforcing bars, shear studs and perforated shear connectors. Due to concentration of stresses originating at the connection of the steel deck with concrete struts, the piers capital are from a high strength concrete of characteristic cubic strength of 60 MPa. The heterogeneous subsoil is formed by limy shale and limestone. Therefore the foundation of the bridge is different. The abutments are founded on spread footings, the vertical piers on drilled piles and inclined piers of wall diaphragms.

According to a studied problem the structure was analysed as a plane or space structure assembled from bar or solid elements. A great attention was devoted to the analysis of the mutual connection of the steel girder with inclined piers. Due to the progressive erection of the deck, changes of the static function and different ages of structural members, a very detailed time dependent analysis of the structure was also done.

2. Construction of the bridge

While the abutments and vertical piers were built traditionally, the inclined piers were progressively cast in cantilevers starting at the piers footings. The piers were cast in segments 2.50 m long in the form travelers anchored at the previously cast segments. The static effects in the erected cantilevers were reduced by erection stay cables anchored in temporary footings with rock anchors.

The steel girder was assembled behind the north abutment and incrementally launched in segments of length up to 55 m from one abutment to the other. The static effects in a launched structure were reduced by using temporary supports and by a launching nose. Two temporary towers were assembled from inventory steel members, two, situated close to the connection of the inclined piers with the deck, were from concrete.

When launching of the steel girder was completed, the progressive casting of the deck slab started. The slab was concurrently cast in two travelers moving along the steel girder from the abutments to the middle of the bridge. The length of the cast segments was from 18.00 to 26.30 m. After casting the two thirds of the deck segments, the piers' capitals and diaphragms, that guarantee the connection of the piers with the deck, were cast. After that part of the load from the temporary towers, were transferred into the inclined piers. When deck slab was completed the temporary supports were released and demolished.

The construction of the bridge started in fall 2007 and finished in september 2010. The client of the bridge was the Road and Motorway Directorate of the Czech Republic. The original design of the bridge was performed by SUDOP Praha a.s., who also started to work on the final design. Subsequently, the final design has been partially done by LAP-Leonhardt, Andrä u. Partner, GmbH. Dresden. Design firm SHP-Stráský, Hustý a partneři, s.r.o. Brno was asked to finalize their design and to take responsibility for all work done by previous designers.

The bridge was built by a Joint Venture of firms from Czech Republic: STRABAG a.s., HOCHTIEF CZ a.s., BÖGL a KRÝSL, k.s. The steel structure was partly manufactured in Czech Republic by MCE Slaný, s.r.o. and partly in Germany by MAX BÖGL UNTERNEHMUNG GmbH & Co KG.

	Total	Per 1 m^2
Structural steel	4 717,0 t	325,11
Concrete C35/45	5 743.8 m^3	0.396 m^3
Reinforcing steel	1 685.8 t	116.3 kg
Prestressing steel	5.5 t	0.38 kg

3. Fiber concrete of the deck slab

In the transverse direction the deck slab has variable depth from 220 mm at the edges to 620 mm at the edge stringers. The deck slab is designed as reinforced concrete member of the characteristic cubic strength 45 MPa, however above the inclined piers and at close to expansion joints the deck is transversally prestressed. To reduce the crack width, following measures were taken; the maximum diameter of the longitudinal reinforcing bars situated close to the surface is 20 mm, above supports, where the composite deck slab is stressed by tension, additional coupled reinforcing bars of 32 mm, respectively 28 mm diameter, were situated in the middle of the slab depth. The concrete was also enriched by polypropylene micro-fibers FIBRREX 12 of 1,35 kg/m3. Fibers are of 12 mm length and 20 µm diameter, white, from C3H6 polypropylene of density 0,91 g/cm3, with elasticity modulus 3000 MPa and tensile strength min. 500 MPa. Fig. 4.

Concreting of the deck slab was prepared in details, the composition of concrete mixture, testing its strength and elasticity development and all other properties according to standards. Special field-tests on concrete blocks were prepared to prove the technological properties important during concreting, curing and also for following processes, for example for waterproofing or surface-finishing. There was no technological problems during concreting and finishing of slab (see fig. 5,6) and its surface caused by addition of polypropylene microfibers. Surface quality was very good and strength in tension exceed 2 MPa (see fig. 7).

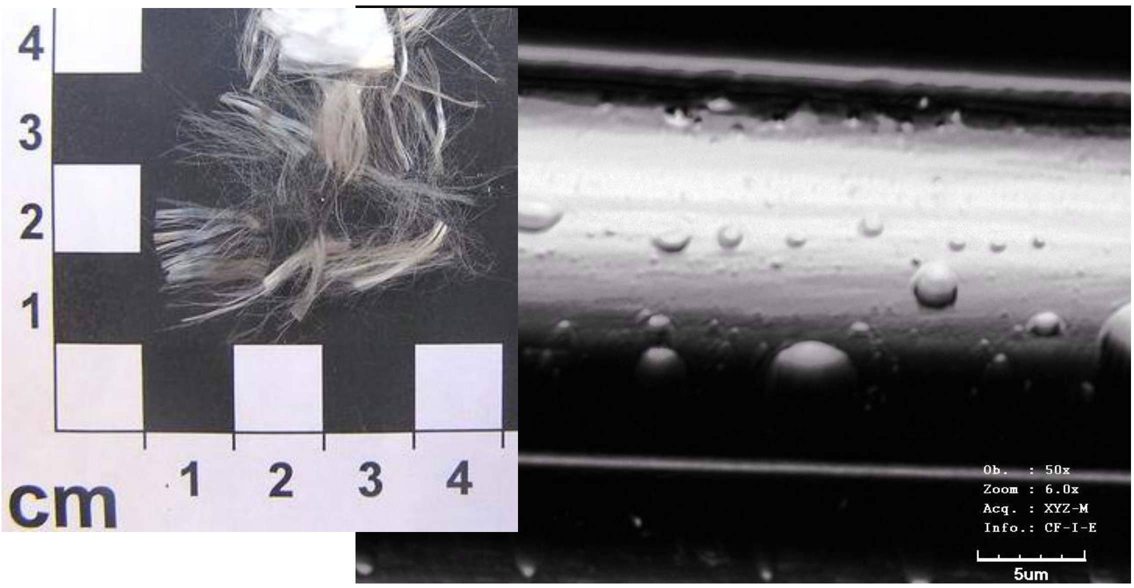

Fig. 4: General view of the PP microfiber Fibrrex 12 and magnified surface of the fiber

Fig. 5: General view of the lying and compacting of concrete with PP microfiber Fibrrex 12

Fig. 6: General view of surface finishing of concrete with PP microfiber Fibrrex 12

Fig. 7: View of surface tension test after cleaning by pellets

4. Conclusions

Nearly 6000 m^3 of concrete C35/45 XF4 modified by dosage of 1,35 kg/m^3 of polypropylene microfibers FIBRREX 12, 12 mm length and 20 μm diameter, were used to produce slab of bridge. Fibers were applied to improve concrete resistance to cracking mainly at plastic stage of concrete. Results of technical inspections and measuring, that were made during the concreting of the deck slab, after first stage of hardening of the respective section, were very good. No penetration of water, also after very strong rains, was mentioned on the bottom surface of the deck slab. Generally can be said, that cracks occurred after few weeks were very fine, most of them up to 0,1 mm, the rest up to 0,15 mm, excepting several wider cracks above piers, where also sun shining is effective and also negative moment causing tension stress in concrete of concrete slab. This state of crack is nearly unchanged until now after one year of service of bridge. In spite of general experience, that the dominant favorable effect of short polypropylene microfibers fibers on cracking development is during the first stage of concrete hardening, it seems that this effect lasts also during all following stages of concrete structures' service-life, for their strength-mechanical properties and of cracks' width. According to our opinion, the use these polypropylene fibers for deck slab of composite steel and concrete bridges is very useful for minimizing of cracks and prolongation bridge's service-life, for very small financial amount.

Acknowledgements

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5. References

[1] K. Dahinter, J. Kolísko, V. Vacek, O. Vich, P. Mařík, J. Šťastný, P. Macháček, "Vláknobeton desky mostovky spřaženého ocelobetonového mostu přes Lochkovské údolí ", *BETON 2/2010,* (BETON TKS s. r. o.) pp 10 – 18.

[2] P. Svoboda, J. Stráský, P. Kaláb, J. Holba, P. Mařík, K. Dahinter, "Bridge across the Lochkov valley", *Structural Concrete in the Czech Republic 2006 – 2009, Nation Report of the Czech Republic,3rd fib Congress Washington 2010, pp 58 – 61.*