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### Europe's largest single pylon stay cable bridge

Timely achievement of unique design for new Sava Bridge

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STAY CABLES

• • WE COMPLETED OUR TASK WITHIN JUST A YEAR – INSTEAD OF THE ORIGINALLY PROGRAMMED 18 MONTHS. • •



bridges are around 25-30 m wide. The stay structure has a 200 m high cone-shaped pylon which was constructed in concrete using selfclimbing formwork. The lower section of the pylon is split into two legs which penetrate the deck between the carriageway and railway track. The two legs merge at a height of 98 m and continue as a single circular shaft – where the stay bearings are placed – up to a height of 175 m. For the pylon's tip – the uppermost 25 m – a stainless steel jacket made of sheet metal is mounted.

The 376 m main span is of steel construction supported by 20 pairs of stay cables which are anchored on the pylon and the superstructure. The extremely long and heavy main span requires the bridge to be counterbalanced by a concrete back span of 200 m which also has 20 pairs of stays. A box section form was chosen to anchor the stay cables in the superstructure. The box section is divided into three cells - two smaller ones on the outside with the anchorages and a wider one - carrying all utility lines - in the centre. The deck slab is supported by a hollow box girder which is 14.5 m wide and 4.75 m high. The outer 15.25 m wide cantilever slabs are supported by raked brackets at four meter intervals. The deck of the main span was formed as a rectangular steel box, also divided into three cells, and weighs 8,600 t in total. The deck units were shipped to Belgrade and unloaded in the preassembly yard, close to the side span, where the sub-elements were stored and preassembled into 16 m long segments.

#### NO PROPS IN RIVER

A stipulation for the bridge's construction was that the main span across the River Sava should be realized without temporary propping in the river during erection. Thus, the free cantilever method – operated from one riverbank – was chosen for the erection of the 21 main span segments. The segments were loaded on a barge at the preassembly

## **On the record:** with Holger Svensson

Dipl.-Ing., Holger Svensson, PE, CEng, is a professional engineer and former Speaker of the Executive Board of renowned consulting engineers Leonhardt, Andrä und Partner (LAP). Recently, he has published a book, *Schrägkabelbrücken – 40 Jahre Erfahrung weltweit*, about stay cable bridge design and construction, based on over four decades of extensive experience of design engineering for major international projects. He now shares a few thoughts and experiences on the Sava Bridge project and cable-stayed structures generally.

Sava is an interesting bridge – its form is that of half a normal cable-stayed bridge, so if you doubled the size you would arrive at a very large bridge indeed. It also has a couple of unique aspects. Firstly, it's the largest cablestayed bridge with a single tower in Europe and, secondly, the sidespan – which doesn't rest on piers over the water – acts as an exact counterbalance to the main span. Originally, the bridge was designed completely in steel to reduce the weight, because the sidespans could only be supported from the shore. LAP submitted an alternative proposal for a hybrid bridge with a steel main span and concrete sidespans – the concrete acting

as a counterweight for the main span. This was a really competitive alternative, as it delivered a significant cost reduction for the client over the steel option. The whole project went extremely smoothly and

extremely smoothly and came in on time and on budget. There were sliding forms for tower construction and sidespans constructed using the incremental launching method – which, incidentally, was invented by

LAP in the 1960s. The 45 m sidespans were quite something – involving extremely heavy weights. The 376 m long free cantilevering

yard and shipped to the correct position under the bridge. A derrick crane, located at the tip of the corbel, lifted the segments which weighed up to 360 t each. After welding, the cantilevered deck was completed, the derrick was moved to the new segment and the new pair of stay cables could be installed.



main span was fabricated in Asia, shipped to site, preassembled and installed – not a unique situation, but it went very well indeed. LAP's relationship with BBR began with the cable-stayed Schillersteg footbridge back in 1960. Fritz Leonhardt thought of using BBR tendons for their strength and stiffness and, along with colleagues, developed a system which later became BBR HiAm. This small bridge, with its parallel wire technology, was the forerunner of whole generations of major cable-stayed bridges which followed around the world.

Today, design challenges are largely around realizing longer spans. The trickiest thing with longer spans is cable dynamics. So, we use three types of countermeasures – profiled sleeves to avoid rivulet formation, dampers



and thirdly, we have the option of using cross-ties, although this is preferably to be avoided. Personally, I believe the casual observer should be able to see the flow of forces, to understand how the structure functions – many cablestayed bridges do this well. Above all, simplicity – this is a golden rule for creating a successful cable-stayed bridge.

Schrägkabelbrücken-40 Jahre Erfahrung weltweit by Holger Svensson was published by John Wiley & Sons Limited in 2011, ISBN 3433029776, 9783433029770, 450 pages. The English version will be available in April 2012.

#### STAY SPECIFICATION

For the stay cables, we used BBR HiAm CONA 5506, 7306, 8506 and 9106 anchors which were preassembled in our specialist workshop in Austria. The number of strands installed in each cable followed the requirement of the design and the sizes of the stay anchorages were chosen to  $\rightarrow$ 

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