CHENAB BRIDGE: CONNECTING THE ARCH UP IN THE CLOUDS

At 359 metres above the Chenab River bed, here comes the world's highest railway bridge

Connecting the halves of the immense arch represents a milestone in the construction of the Chenab Bridge. The new bridge is part of the Udhampur-Srinagar-Baramulla rail link project in the Jammu and Kashmir region in India, circa 600 kilometres north of New Delhi. The project—which aims to enhance transportation to and from the region and join the Kashmir Valley to the Indian Railways network—continues toward completion, expected by the end of 2022. In March this year, the design and construction teams closed the bridge's arch over the Chenab River between Bakkal and Kauri.

Design Director Pekka Pulkkinen and Technology Director Risto Kiviluoma, WSP in Finland, discuss how the design and construction teams achieved the "arch" milestone. They also address wind engineering as well as other design-engineering requirements.

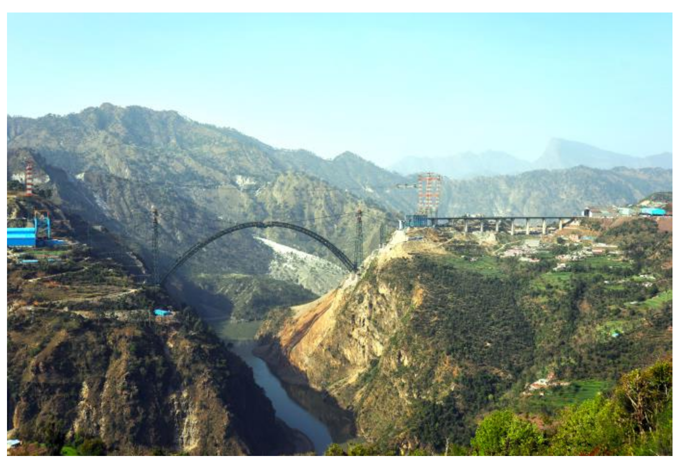
Facts

- Highest steel arch bridge for railway traffic in the world, 359 metres above the river bed; the length of the arch is 467 metres; the total length of the bridge is 1,315 metres
- Designed for heavy wind loads and earthquake zone V as per the relevant IS Codes
- All steel structures are modelled by 3D TEKLA software, which ensures compatibility of members during erection; the total amount of steel is 27,000 tons
- Erection of the arch was done by suspension cable crane
- The bridge has been designed for blast load
- Critical members are designed for adequate redundancy and operation at the lower level of efficiency

Client: Konkan Railway Corporation Limited (KRCL) on behalf of Northern Railway

Parties involved: Contractor— Afcons Infrastructure Ltd, India; Designer—WSP Finland Ltd with subconsultant Leonhardt & Andrä und Partner, Germany

Timeframe: Started in 2005; the arch was connected in March 2021; estimated completion–in 2022



The image above shows the closure of the bridge's arch over the Chenab River in India — between Bakkal and Kauri in the Jammu and Kashmir region, in the northern part of India. The railway will be built over the arch.

Bridge Challenges

Connecting the Arch

Pekka Pulkkinen, Design Director, WSP in Finland

The Chenab Bridge is a major achievement—for all the bridge designers and builders involved in the project. The erection of the arch, a truly memorable moment, represents a great execution of engineering expertise. Cooperation between the design team and contractor has been essential for the project's advancement. The challenges in the project have been handled together, thereby facilitating the successful solutions.

The steel arch halves were connected in late March 2021, marking years of commitment, as many of the designers have been working on the project from the beginning, year 2005. The bridge has numerous design challenges, such as the erection of the steel arch by cable crane, the bridge's huge dimensions, and the special design requirements—redundancy of the arch, the earthquake load and blast load effect.

The erection of the steel arch segments was done with a suspension cable crane, which can lift one 35-ton steel block at a time. The arch was erected by cantilever method. Halves were hung on both sides with steel cables that were attached to the bridge foundations. All the steel blocks are bolted together. Steel truss pillars will be installed next on top of the connected arch. The steel superstructure of the bridge will be launched over the steel truss piers from both directions, and the joining will take place in the middle of the arch. Finally, rails will be installed on the deck for train traffic. The approach portion of the bridge has already been completed.

Figure 1 – Side view from the foundations

Figure 2 - Final moments before connecting the arch with engineers working on both levels of the arch

Wind Engineering:

Risto Kiviluoma, Technology Director, WSP in Finland

The main challenge in wind engineering was not the size of the bridge itself but the site and altitude at which it is located. In extremely rough topography, standard models of wind and turbulence are unlikely to be realistic; a special type of wind tunnel testing was therefore conducted to assess the design wind parameters.

Wind engineering of the bridge was conducted by combining in-house wind engineering expertise and the wind tunnel tests of FORCE

Technology in Denmark. The first test involved a large-size topography model of the bridge site. It revealed some unusual wind characteristics, including up to 11 degrees vertical inclination of the mean wind velocity and wide scatter of turbulence intensity from 7 percent to 55 percent, depending on wind direction.

The next test in the program was standard section model testing, which contributed updated aerodynamic input to WSP's advanced 3D buffeting analysis and equivalent static wind load extraction. Buffeting results were further confirmed with full aeroelastic model tests.

Subsequent design changes and construction stages were assessed computationally, i.e., without extra testing.

Thanks to truss structures in the arch and the piers, the bridge is not sensitive to aeroelastic instabilities, but the lateral wind load itself was of main interest. This was due to the need to control lateral displacement of the deck for smooth railway operations.

The construction site has so far been free of major storms, though during the 120 years of design service life of the bridge they will likely occur. Continuous surveillance of wind conditions and a warning system will help manage rail traffic.

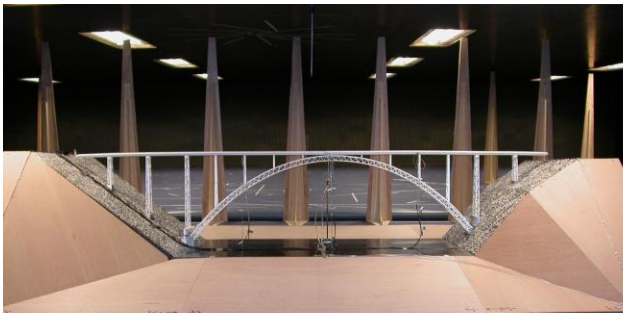


Figure 3 - Full aeroelastic model of the bridge in a wind tunnel

<u>On Cloud Nine</u>

Giridhar Rajagopalan – Executive Director Technical at AFCONS Infrastructure Limited, India

Chenab Bridge, which is slated to be world's tallest railway bridge, is a source of pride for India and a lifetime opportunity for those who worked on it.

Going forward, we are on track to complete the bridge a year from now and eagerly anticipate traversing India's bridge in the clouds.

Figure 4 – Connecting the arch up in the clouds

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