The Chiani Suspension Bridge: A Complete Overhaul

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Summary

The paper presents the total rehabilitation of the Chiani suspension bridge in Algeria. The bridge, designed by the French engineer Arnodin at the bout of the last century span 105 metres using a mixed cable supporting system with a stayed deck portion near the towers. The bridge was designed and built before the similar Sidi M'Cid one in Constantine.

The authors have been asked to engineer a complete overhaul of the bridge, a beautiful structure completely abandoned and closed to traffic because of its severe state of degradation. The works included the complete substitution of the suspension system, widening of the superstructure with new pedestrian walkways moved out of the parapet girders and a new concrete deck to allow unrestricted vehicular transit.

An innovative suspension system with resin encased strands has been used for the main cables, stays and hangers replacement in lieu of ropes and steel bars. New saddles, made of welded plates following a concept originally developed for the 3rd generation suspension bridges, have been placed over the existing ones with the two systems working in parallel during the load transfer.

Keywords: Suspension bridge, cable substitution, deck widening, strands, saddle, clamps.

The Chiani bridge rehabilitation main features

Various existing small to medium span suspension bridges built in the late 19th and early 20th century are now in need of strengthening and repair. Very often it is now time to replace the main suspension cables that given their reduced diameter and lack of proper protection are more prone to corrosion compared to those used for major suspension bridges.

The Chaini bridge was supported by two cables, each one made of 6 ropes. Clamps and hangers were closely spaced at 1.25 metres centre holding I-type cross beams supporting the deck. Twenty metres each side of the towers the deck was supported by 6 plus 6 stays (ropes). The deck stays are anchored to two stiffening I-beams that run beneath the stayed portion of the deck. The opposite horizontal force components of the stays are balanced by 2 traction ropes running below the deck along the suspended part and connecting the above-said I-beams. The saddles originally could slide on rollers; this mechanism, although showing extensive sign of deterioration, must have been still effective at the time of rehabilitation judging from the perfect condition of the stiff masonry towers. All the elements of the suspension system showed severe signs of deterioration. Stays had quite a few broken wires hanging loose, cables were still locked but close inspection after their removal showed corrosion had reached the inner wires with localised pitting phenomena.

The metallic part of the superstructure was made of two parapet stiffening girders and transverse I

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beams spaced at 1.25m centre supported by the hangers. Both elements showed extensive but still superficial corrosion. The running surface of the deck was made of wooden planks in a very poor state, falling apart and leaving wide gaps so that the bridge was officially closed to traffic although still providing factual crossing for pedestrian, small motorbikes and herds along the two steel clad kerbs running besides the two parapet girders.

In order to open the bridge to vehicular traffic it was decided to cast a concrete slab on top of the transverse beams in between the two parapet girders. While providing a firm surface for vehicular traffic the slab would also strengthen significantly the bending and axial behaviour of the superstructure. Thickness of the slab has been kept to a minimum (14 cm) so as to reduce its weight. The slab was cast onto corrugated steel sheeting for increased punching and bending resistance. Still, the new concrete slab made for an hundred percent increase of the deck self weight with respect to the original configuration.

In order to allow for vehicular traffic to run onto the new deck, two other aspects had to be addressed, namely: transverse beams had to be strengthened and kerbs displaced to make place for a single lane carriageway in between the parapet girders. Strengthening of the transverse beams was obtained by welding additional plates onto the bottom flanges and stud connectors on the top ones so as to obtain composite action with the concrete slab. Sidewalks were moved outside of the parapet girders. This displacement required the transverse beams to be extended with additional steel plates bolted onto their webs so as to support the new sidewalks positioned in between the parapet girders and the new hangers. The hangers had also to be displaced half a metre outwards thus swinging the suspension cables from the slightly inward original position. Additional plates were also welded onto the upper chords of the parapet truss girders increasing the upper chord lateral and torsional stiffness and the girders buckling resistance.

The new saddles are composed from an assemblage of smaller components made of rolled and welded plates instead of being a single casting. The old saddles have been encased in a steel box, cement grouted once the old cables and stays were removed. The new saddles are placed on top of these encasings on Steel-Teflon bearing pads that allow longitudinal displacements.

Main suspension cables are made of epoxy coated prestressing strand arranged in 3 ropes of 13 strands on each side. Clamps, kept at their original spacing, are made of two parallelepiped castings bolted together. Hangers are made of two strands each fixed to the camps with standard mono-strand prestressing anchorages. Between hangers and transverse beams, high strength treated bars are interposed to allow for easier and finer final tensioning.

The new suspension cables and stays are anchored in cast-in-situ reinforced concrete blocks connected to the existing anchorages. These anchorages were made of concrete cast inside pits bored in the rocky ground. The pits were large enough to make room for the new reinforced concrete castings. The additional weight of the new casting, provided sufficient strength for the increased weight of the suspension bridge.