Reinforcement and Infrastructures Rehabilitation of the Steel Mix International Bridge over the Minho River at Valença, Portugal

Miguel GUIMARÃES
Civil Engineer, MSc
Struconcept, lda
Porto, PORTUGAL
Miguel.Guimaraes@struconcept.com

Born 1965, received his civil engineering and master degrees from University of Porto, Portugal. Partner at Struconcept. His main interest is structural engineering and rehabilitation

Alberto TEIXEIRA
Civil Engineer, BSc
Struconcept, lda
Porto, PORTUGAL
Alberto.Teixeira@struconcept.com

Born 1965, received his civil engineering from University of Porto, Portugal. Partner at Struconcept.
Strong skills on steel structures.

Summary

This text addresses some of the major aspects for the reinforcement and rehabilitation of the infrastructures of the international bridge over the Minho River at Valença, Portugal, a steel lattice girder box for road and railway service, with granite masonry columns and abutments.

Keywords: Steel Bridge, Masonry, Lock-Up Devices, Anchors, Foundation Assessment and Repair.

1. Introduction

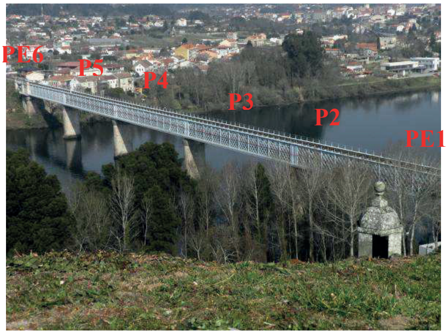

Fig. 1: The bridge seen from Valença fortress (left bank on portuguese side)

Dealing with this elegant bridge of 1886 was challenging, as it is a landmark linking two character towns by the river, Valença (Portugal) and Tuy (Spain).

The superstructure is a steel multiple lattice girder that supports having two decks, the superior carrying a railway line and the inferior the roadway, presents 5 spans up to 69m, total length of 333m. Margin transition spans extends the upper deck up to 399 m continuous rails between joints.

Intermediate support (P2 to P5) are granite masonry columns rising 15 m above water level, descending trough the river sand until it reaches bed-rock or gravel bed.

Abutments (PE1 and PE6) are quite elegant vaulted masonry constructions that allow the road deck to gain way from the lateral access, bearing directly in the granite.

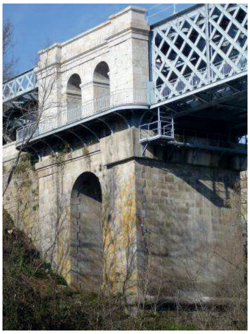

Fig. 2: Abutment on right bank

2. Bridge assessment

This bridge was investigated and refurbished with ingenious yet often simple techniques, showing several pathologies on the masonry elements due to inadequate concentrated force transmissions, as caused by the bearing devices over the columns, which are not rotulated, causing excessive rotations on the top, so had to be changed. Additionally, one column exhibit a great underwater cavity at bottom level, detected with accurate rigidity estimation of bearing devices and columns from the observation of thermal movements of all bearings.

Topographical (tacheometry and 3D photogrammetry by photo restitution), bathymetry and geotechnical surveys were also made, so we

https://doi.org/10.2749/222137813806478918

could distinguish soil found inside the columns from the surrounding soil and also to better evaluate scour susceptibility. Also relevant the detection of a variable thickness (up to 10.5 m) layer of gravel bed with glacial origin that, despite its highs stiffness, needs to keep its confined condition even in scour occurrence, influencing the project definition.

Fig. 3: P2 view and bearing displacement detail

Test results shown a consistent situation of an acceptably resistant concrete (fc = 27 MPa), not significantly attacked by chlorine but with carbonatation progression beyond the covering layer, so protection is needed to avoid deterioration development. Granite stone is quite uniform, with resistances up to 36 MPa, which is satisfactory but denotes quite soft granite. Its young modulus is also low, about 6 GPa. Being so, this stone is also prone to meteorically attack, showing extended wear like exfoliation and some fissuration.

It showed inadequate provisions to withstand the train breaking action, so after several studies, lock-up devices were adopted above the bottom chord of the truss, so reacting to almost actions demanding the bridge: Live load (road/railways - flexural effect), breaking action (direct effect), wind (flexural effect), thermal actions (direct effect) and a provision for asymmetry were considered, evaluating the intensity versus frequency and duration of each load case, with a "soft"/"hard" model of the bridge supports.

This system relies on new reaction anchored slabs in the abutments. Special steel structures were developed to strap these devices to the truss in a compatible, yet discrete way. To withstand the forces involved, soil underneath the slab was reinforced with jet grouting technic, as well the alluvia soil around the columns, to prevent scour effects.

Existing steel foundation casing will also be changed, considering its degraded state, by a new concrete casing.

Reinforcements of the truss were necessary to allow changing the existing bearings of the truss. All these new steel structures were highly demanding on conception, for compatibility with the existing one.

Masonry elements were repaired with compatible mortars and protection impregnation, and the bridge should be instrumented.

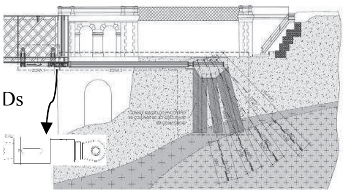

Fig. 4: LUD force transmission system

3. Conclusions

A comprehensive investigation, and the deep exploitation of simple to acquire data like thermal displacements, let the development of an important refurbishment of the bridge, yet without corrupting its elegance and character. Analysis like this one could be easily implemented and, also, data acquisition could be easily automated, so any pattern changing in this behaviour could in many cases give important warnings much before vertical settlements or other evidences could also do so.

4. Acknowledgements

Deserve a special reference for the assistance on the development of this project: Prof. Mota Freitas and Engº Ricardo Bahia. Concerning the solution and equipment adopted, reference must be made to Mr. Philippe Duflot (Taylor Devices) and Eng. José Monteiro (Fibersensing) for their important contribution. Owner representatives had a great influence on the solution and its good adequacy to the execution: Eng. Fernando Martins, Hugo Fernandes and Engº Pedro Campos (REFER).