SHM of the new bridge over the River Sado in Portugal during construction

Luís OLIVEIRA SANTOS
Senior Research Officer
LNEC
Lisbon, Portugal
luis.osantos@lnec.pt

Luís Oliveira Santos, born 1964, received his civil eng. degree in 1987 and his PhD in 2001, both from the Technical University of Lisbon. His research interests include monitoring, testing and assessment of bridges.

Min XU
Research Officer
LNEC
Lisbon, Portugal
xumin@lnec.pt

Min Xu, born 1964, received her marine eng. degree in 1986 from Jiao Tong Univ. of Shanghai and her PhD in 1995 from T. Univ. of Constr. and Archit. of Kiev. Her research activities consist in monitoring, modelling and analysis of structural behaviour.

João Pedro SANTOS
PhD Groundholder
LNEC
Lisbon, Portugal
josantos@lnec.pt

João Pedro Santos, born 1982, received his civil engineering and degree and MSc in structural engineer from the Technical University of Lisbon and is preparing a PhD dissertation on Data Mining applied to Structural Health Monitoring.

Summary

The new railway crossing over the River Sado is a 2,7 km long bridge, including two approach viaducts and a main bridge. The main bridge, with a continuous deck over 480 m, consists of three continuous bowstrings with a single plane of hangers on the bridge axis. The bridge is located in an environmentally sensitive area which conditioned the design and the construction methods used.

The bridge importance, its structural complexity and the innovative constructions methods used were the main constraints and motivations for the development of the implemented structural health monitoring system, which is described herein.

Keywords: structural health monitoring, bowstring arch bridge, bridge construction, incremental launching

1. Introduction

The new railway crossing over the River Sado, at Alcacer do Sal, consists in a large bridge with a complex structural system, built by innovative construction methods and in an environmentally sensitive area. These were the main reasons for the installation of a structural health monitoring system in the bridge, but also acted as constraints for its development and implementation

After a brief description of the bridge and the construction methods used, this paper presents the bridge structural health monitoring system, including the different types of equipment used in order to get more accurate measurements. The focus of the paper is the experimental results obtained during some critical construction operations like deck incremental launching and arches' hoisting.

2. Bridge description

Fig. 1: General view of the bridge

The new railway crossing over the River Sado has a total length of 2,7 km, including two approach viaducts and a main bridge.

The main bridge, with three continuous spans of 160 m, is a bowstring arch bridge, with three continuous bowstrings with a single plane of hangers on the bridge axis (Fig. 2). There are 18 hangers in each span, 8 m apart. The bridge deck has a steel-concrete trapezoidal composite section, 15,85 m wide, allowing the installation of two railway tracks. The steel arches have a variable hexagonal cross-section, with the width increasing from 1,49 m to 3,20 m towards the top.

https://doi.org/10.2749/222137813808627118

3. Bridge construction and incremental launching

The main bridge construction involved the following major operations: the incremental launching of the deck, the hoisting of the arches, the connection between the hangers and the deck and, finally, the slab deck concreting (Fig. 2).

Fig. 2: Bridge construction: deck incremental launching and arch elevation

4. Monitoring during deck incremental launching and arches' hoisting

The bridge structural health monitoring includes the measurement of deck rotations and vertical displacements, strains and temperatures in both deck and arches, as well the joints movement.

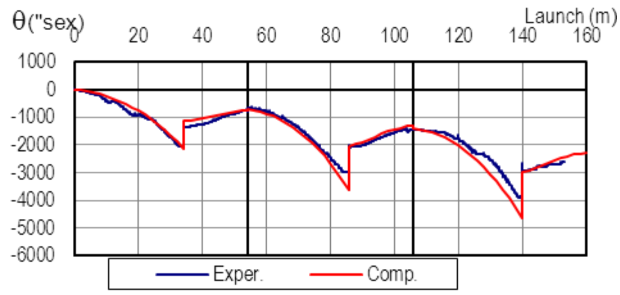
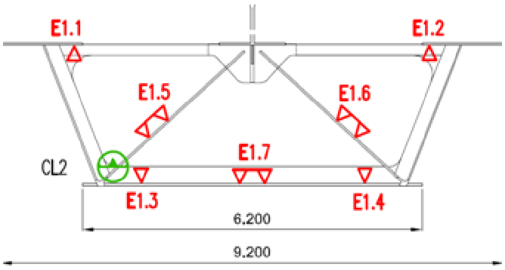


Fig. 3: Rotations at the cantilever free end

The incremental launching of the deck was vital in the conception of the structural monitoring system, mainly, regarding the first span.

Fig. 3 presents the rotations in the cantilever free end during the incremental launching. The rotation was greater than 1 degree, with an obvious correlation between calculated and experimental values.

Deck cross section S1 was instrumented with seven strain gauges placed as presented in Fig. 4. Top and bottom flanges strains measured at section S1 during the incremental launching are presented in Fig. 5 along with the numerical results.



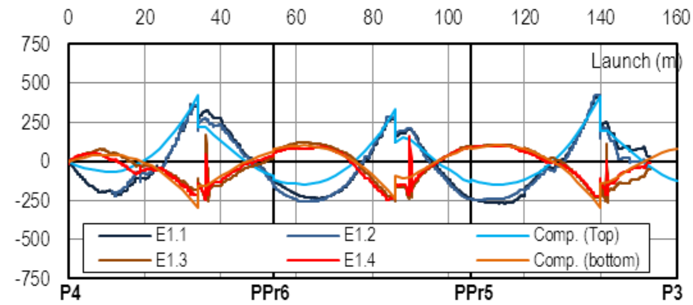


Fig. 4: S1: strain gauges location *Fig. 5: Strains at S1 during incremental launching*

The mid-span sections of each part of the three arches were instrumented with strain gauges and thermistors, with purpose of confirm the efficiency of the construction process in the elimination of bending moments installed on the arches during its hoisting.

5. Conclusions

A main contribution of the used SHM strategy during construction was the ability to check in real time the performance and efficiency of the adopted construction methodologies. Another important asset of the monitoring carried out, is the knowledge that throughout the construction the actual behavior corresponded to expectations, not having been induced excessive stresses that could cause permanent deformation.