Application laser scanning in geometric analysis

Using laser scanning for the geometric study of Alcántara bridge.

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Introduction

Alcántara Bridge is situated in the locality of Alcántara (Cáceres, Spain). It was finally built between 103 and 106 AD., and it is an arquitectonical monument made in granite ashlar through “opus quadratum”, alternating by spinning rope and header, excepting in the beginning of the arches, which due to the necessity of the truss support for the arches’ performance, were totally made by header. Ashlars are dry joined helped by horizontal staples in dovetail [1].

The bridge measures 191,37 meters long, a wide road of 7,836 meters reaching a maximum high at water level in the central bowl of 37,98 meters until petrila culmination.

Through history, Alcántara roman bridge has resisted floods and earthquakes [2]. Its geographic localization has let it be witness of military events, some of them have damaged part of its structure.

First damages were noted in 1218, when Alfonso the eleventh ordered to his knights to destroy the first arch of the right shore, awarding later the reconstruction building to Marin López master.

The bridge suffered again a new damage in one of its arches in 1648 during Restoration War between Portugal and Spain, and the military engineer Diego Bodick was the responsible to rebuild the bridge in 1778 with some damages created in 1707 by the Portuguese army. Finally, lot of graphic manuscripts of the last restoration which is noted in 1858-60, when the arch destroyed by the English and Portuguese armies when they tried to avoid French army entrance. In this last event,
engineer D. Alejandro Millán participated to leave the bridge as can be seen nowadays [3]. One issue to take into account is the involvement of the public administrations in the maintenance and restoration of the cultural history patrimony. The monument which is categorized as National Patrimony and it is urging to UNESCO to state it Humanity Patrimony.

Data Collected

Data collected were carried out through scan laser Leica Scanstation C10, with 300 meters reach and 90 % reflectivity. Due that the device extrapolates the shape of a point cloud through it has been made the later work of join and collection modeling. To obtain the geometric through scan laser of the bridge, 10 scans have been made distributing in both sides of the bridge, so each scan has got a point cloud of nearly 6,5 points millions. Once we obtained data with scan laser, we have developed the union of the collected data carried out through Cyclone v7.1. software [4], through we recognized reveilles collocated in the moment of the scans, as can be seen in the figure 1. After join all scans, we have proceed to the tridimensional modeling of the bridge through Trimble Realworks v6.5 [5], through we have obtained horizontal, transversal and longitudinal sections of the bridge for the later analysis, as can be seen in the figure 1.

![Figure 1: Longitudinal section of Alcântara bridge.](image)

Data Analysis

We have obtained a cloud of 65 millions points, which equivalent to a point for every 10 cm². This led to a precision of the collection of 0,8 cm for each 100 scan meters, which involves to a total mistake of the Alcântara bridge of 1,5 cm in its length. Obtained measurements of each arches, bowl and support which conforms the bridge, as can be seen in table 1. Nevertheless, it has observed a significative difference regarding lights in arches 1 and 3. This may suggest two possibilities with respect to data interpretation, or might be due to the reused of the truss of every arches, after being executed each arches thread. On the other side, it might be due to a possibly deformation of the
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Triumph arch has a collapse in its top part of 23 centimeters in the first arch.

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Table 1. Measurements in meters of the lengths of the arches lights and bowls’ wide.

Structural Analysis

It has carried out a study to calibrate the resistance characteristics in the brickwork and the structural model of the bridge, considering data obtained of the work of the history documentation and the geometric obtained through scan laser. In the reference [6] it indicates that after decentering the arch 5 rebuild by engineer Millán, decrease the key 1,5 cm. Calibration has consisted in the performance of several models, lineal and non lineal, which decrease in the key and damage is adjusted to the maximum [7].

The model arch has a 1,70 meters thick. It is consisted by gravity brickwork with an initial damage unit of initial damage of 4,250,00 N/mm² and a Poisson coefficient of 0,2. To get the non lineal behavior model it has considered that brickwork has a resistance to an infinity compression and it does not resist tractions.

In the calibration it has verified that the behaviour model which best simulate the decentering is a module of damage of 1,000,00 N/mm²; considering the high thread of 0,50 meters as death weight and triarticulate with labels in its supports and key. In this case the decrease in the key is 38,4 mm (figure 2).
Conclusions

In this communication, we emphasize the importance of the history analysis of the structures and real geometric, to achieve a real structural analysis. In Alcántara bridge, movement data of the key and real bridge geometric, has let us to adjust the model to the calculation. Thus, we were able to verify that in this structure, to adopt the damage module of the brickwork through references give us a significative mistake regarding we obtain through the calibration of the model with real geometric and history data.

Acknowledgments

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References