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The Roman bridge of Canosa di Puglia: a metrological approach

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***Abstract* – The Roman bridge of Canosa (Southern Italy) was built in the 2nd century A.D. to cross the Ofanto river along the *Via Traiana*, the route that connected Rome with the port of Brindisi, on the Adriatic Sea. Over the centuries, architectural transformations have deeply altered the original structure, making it lose the traces of the monumental central arch. A metrological approach in the study of the monument has proven to be essential to formulate hypotheses about the original configuration of the bridge and to include its central span as one of the longest among the bridges of the Roman age.**

I. INTRODUCTION

The study of the ancient monuments is often characterized by the encounter of gaps, both documentary and architectural, which make it difficult to interpret the artifact. This difficulty also lies in the use of a different construction vocabulary in the ancient world whose alphabet is inevitably made up of measurement systems that cannot be superimposed on the ones used nowadays, globally recognized in the International System of Units. The peculiarity of ancient measurement systems falls within the definition of context, which is essential in any type of archaeological investigation, especially when it comes to architectural artifacts. An interesting case of *a posteriori* investigation through these levels of reading concerns a stone bridge, dating back to Roman Age, located along the Ofanto river near Canosa di Puglia, in Southern Italy. Before reaching its present conformation, the bridge is described in a number of ancient documents as having only three arches, of which the central one stood out for its monumental *grandeur*. This characteristic is common to many Roman bridges and is due to the intent to cross the course of the river with an arch as wide as possible, a structure that automatically increases the height at the centre which is higher than that of the abutments and outlines the visible inclination of the ramps. The result is a donkey-back shape with a curved line and massive supports in contrast with the thin thickness of the arch in correspondence of the keystone. The aim of this research is to reconstruct the profile of the monument following the processed data.

Fig. 1. The bridge of Canosa di Puglia. View from West. (photo by G. Germanò)

II. BACKGROUND

A. The bridge today

Currently the bridge (Fig. 1) is divided into five arches of different sizes and morphology (starting from the East: 6.50 m, 13 m, 12.10 m, 12.10 m, 13 m) based on four piers of different sizes, ranging from a minimum of 6.2 m to a maximum of 8.4 m. These are composed of square blocks in isodomic work and equipped with triangular starlings and pyramidal cones, upstream and downstream. The walkway above is developed for a length of 170 m and a width of 4.5 m, its trend is not straight and in correspondence of the abutments. Of the original structure remains only the piers (Fig. 2), the abutments, and the foundation *platea* [1].

Fig. 2. Canosa. View of the western pier of the bridge. (photo by G. Germanò)

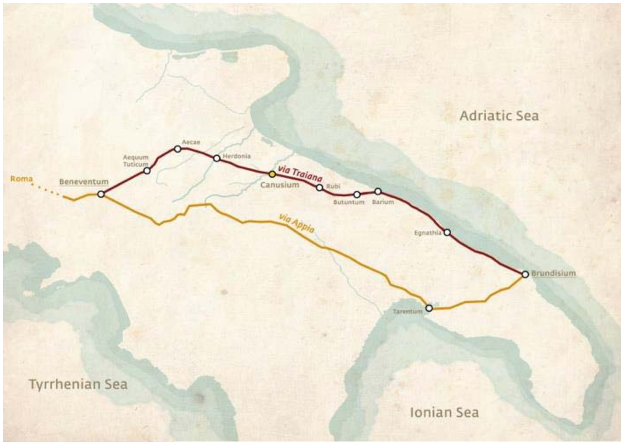

Fig. 3. Via Traiana and Via Appia (map by Germano Germanò)

B. *The bridge in the Roman Age*

The original structure was erected on the occasion of the construction of the *Via Traiana* (Trajan Way) in 109 A.D. by the homonymous Emperor, starting from Benevento, to create an alternative to the *Via Appia* that would allow a faster connection between Rome and Brindisi, the main port towards the East (Fig. 3). Being on a route already in use before, the *Via Minucia* [2], it is not clear if there was already a bridge prior to the imperial age. In any case, the presence of a well-preserved foundation stone paved *platea*, reveals an *ex novo* construction which is consistent with the construction techniques of the imperial age.

First works of restoration are documented in Roman times through inscriptions [3] that attest repairs under Septimius Severus and Caracalla, in the Tetrarchic age, between the end of the 3rd century AD and the beginning of the 4th century AD and in the Constantinian age. However, no numerical data relating to these operations are reported.

ridge in Middle Ages

iddle Ages the bridge was still in use, since it d along the *Via Francigena*, a road through which Christian pilgrims from all over Europe reached the ports of Puglia to the Holy Land. In the Middle Ages even flocks, herds and shepherds used it when they seasonally migrate from the altitudes of Abruzzo and Molise to the plains of Tavoliere with a milder climate, through the so called "*tratturi*" (drover's roads), one of which was passing right through here.

During this long period new works were certainly necessary, but these are not documented until 1521, as the fragment of an inscription, reused in the Mausoleum of Boemondo d'Altavilla in Canosa, would bear.

The first report has been provided by an Italian traveler who at the end of the 16th century described the bridge as "wonderful" and reported the size of the central arch: 128 palms long and 40 palms high [4].

D. *18th century: first survey, the collapse and the reconstruction*

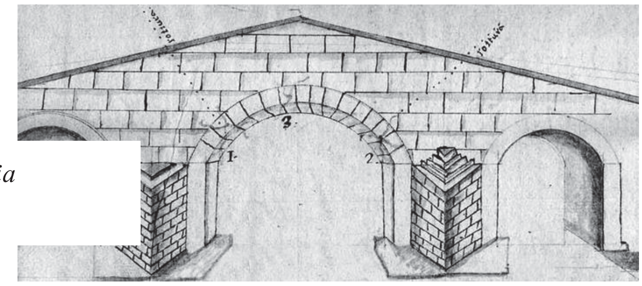

Fig. 4. Drawing of the bridge by Francesco Delfino, 1749, detail. (Archivio di Stato di Foggia)

More than a century later, earthquakes, floods and wear and tear would weaken the structure of the bridge, making further restoration work necessary. The institution in charge of its maintenance, as belonging to the area of its domain, was the *Regia Dogana delle*

Pecore (Sheep Customs Office), established in nearby Foggia in 1480. The documents relating to the interventions of the eighteenth century are still preserved in its archives [5].

In these archives it is stated that in 1749 a technical expert's report was commissioned to Francesco Delfino in which he warned of the dangers of stability. Attached to it, he schematically drew an architectural representation of the bridge in which he indicated the possible breaking points (Fig. 4). In the same document he also reported the exact measurements of the arches:

"[…] the main arch (is) 112 palms wide, high from the floor to the top (of) 44 palms, with a front of 5 palms, (while) the two lateral arches are wide 50 palms each, and high 25 palms".

Due to the stalling of a targeted action that inevitably would have involved large costs that none of the parties involved wanted to bear (Customs, the Crown, local administrators and landowners) the central arch collapsed on 11 February 1751.

Several considerations were made by technical experts who immediately intervened afterwards in the matter, among which, in the end, a safer reconstruction prevailed, but which would have definitively changed the millenary aspect of the bridge. In fact, it was decided not to rebuild the central arch but two smaller ones in its place resting on a newly built central pillar, thus lowering the profile of the bridge to a height similar to that visible today.

The latter, however, does not date back to these interventions because the current structure is the result of a reconstruction carried out in the mid-twentieth century, after the retreating German troops in World War II bombed the bridge, of which only the piers and the abutments were saved.

III. METHODOLOGY

A metrological approach has been used starting from the survey of the current state, comparing it with measures from previous phases mentioned in sources from different eras and cross-referencing them by synchronic or diachronic conversion of numerical data. The first case applies for historically and culturally related contexts, while the second case implements a multi-layered reading of different ages.

Discarding the parts ascertained as added or reconstructed, only the original elements still *in situ* were taken into consideration. Finally, a reconstructive hypothesis of the original morphology of the monument was formulated, based on Roman construction and measurement methods.

A certain degree of approximation is to be expected both in reporting the measures and, consequently, in converting them to reconstructive hypothesis. However, the margin of error is limited enough to consider the data as valid for the purpose of the research.

IV. DATA ANALYSIS

The fundamental unit of measurement (Tab. 1) used during the Roman age is the foot (*pes*) and follows closely the measures of its Greek counterpart, the Attic foot, corresponding to 0.296 m [6].

The authors of the two reports describe the bridge using the same unit of measurement, i.e. the *palmo*.

As the two cases, 1584 and 1749, fall within the time span of the dominion of the Kingdom of Naples, which included the whole of southern Italy, we have therefore to assume that they were referring to the Neapolitan palm, corresponding to 0.26367 meters [7], calculated on the basis of the measurement of an oxidized bar kept in Castel Capuano in Naples used as the governmental standard [8], according to an edict (lost) issued on 6 April 1480 by Ferdinand I of Aragon and in force until 1840. Applying a metrological approach it is possible to derive different hypotheses about the construction phases of the bridge.

Table 1. Units conversion

Unit	Roman Feet	Neapolitan Palms	Meters
Pes	1	1.1225	0.2960
Palmo	0.8909	1	0.2637
Canna	7.1270	8	2.1096
Meter	3.3784	3.7922	1

A. Synchronic conversion: what happened between the two key dates (1584-1749)?

A first conversion, of synchronic type, is made within the same measurement system to hypothesize the changes between the two sources key dates: it is interesting to note that both measurements are a multiple of 8. In the Kingdom of Naples, the unit of measurement that follows that of the *palmo* is the *canna*, which measures exactly 8 palms. Reading it in multiples, the 1749 survey describes an arch span reduced from 16 to 14 *canne*, exactly one *canna* per side (2.1 meters). A margin of error of 4.2 meters appears too large for a width of about 30 meters. One possibility is that consolidation works were necessary following one or both of the devastating earthquakes, the first in 1627 and the second in 1731 [9], which struck the Capitanata and in particular Canosa. In this sense, the work may have involved the overlaying or covering of the inner part of the pillars with a masonry reinforcement designed on the basis of a standard building measure, i.e. one *canna*.

Within Delfino's design there are two elements protruding from the piers, an unusual fact that supports this hypothesis, as an expert surveyor would hardly have invented or exaggerated, despite the evident schematization of the work.

Table 2. Diachronic measures conversion chart

Element	Palms	Meters	Roman feet
Main arch (span)	112	29.53	99.78 ≃ **100**
(height)	44	11.60	39.20 ≃ **40**
Lateral arches (span)	50	13.19	44.54 ≃ **45**
(height)	25	6.59	22.27
Front	5	1.31	4.45

B. *Diachronic conversion: reconstruction hypothesis*

On the other side, through a diachronic conversion of the units of measurement (Tab. 2) it is possible to read the dimensions of the work with the same measuring instruments of the Roman manufacturers. As previous said, the central arch was imposing and larger than the other two, as shown by Delfino's drawing and, even if with a more simplified style, other graphic sources preserved in the archives. Therefore, if we accept the dimensions reported in the document (112 palms) and hypothesize them as unchanged as compared to the Roman age, having assumed the lateral piers as dating back to the imperial age, we obtain a measure (29.49 m) that is, with the due margin of error, exactly corresponding to 100 Roman feet.

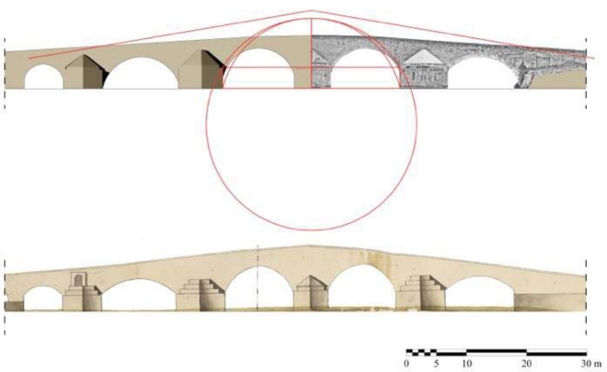

Fig. 4. Upper, the bridge nowadays with the geometrical construction of the hypothesized shape . Lower, detail from a survey of Amato Poulet, 1756, now held in State Archives of Foggia, Italy.

This measurement is an architectural constant of the monumental Roman architecture, present in one of the most famous monuments of the Emperor Trajan, its column called "*centenaria*" for its height, the Aurelian column and, later, the hall of the palatine basilica of Constantine in Trier, but also the diameter of the mausoleums of L. M. Planco and Sempronius Atratino and the most famous pyramid tomb of Caius Cestius, whose side measures exactly 100 Roman feet.

Also the height, 44 palms, would correspond to about 40 Roman feet, still a multiple decimal number, but this data is subject to more variables since in case of restoration or collapse the section of the arches is the part most exposed to sensitive alterations. Moreover, it must be considered that it is not indicated in the sources whether the measurements were taken at the height of the water or the foundation *platea*.

Given these measurements, therefore the arc of the circle tangent was traced to the ideal segment at the level of the piers, about 3 meters high, obtaining a figure that outlines a donkey-back profile (Fig. 4), based on a comparison with similar bridges, such as that of Ascoli Satriano on the Carapelle river (2nd century AD) and the Pont Julien at Bonnieux, in France (Augustan age).

Fig. 5. Northwest front of the bridge, abutment. The red line shows the probable original incline still identifiable in the grade of the rows of blocks.

The inclination of this profile corresponds to that found in the joints of the abutments (Fig.5), especially on the western side, which would confirm the presence of the original outline of the bridge (Fig. 6).

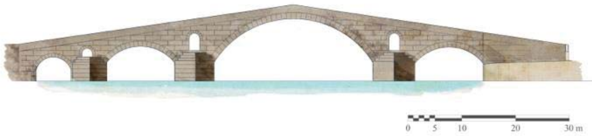

Fig. 6. Graphical reconstruction of the bridge of Canosa in Roman times. (elaboration by Germano Germanò)

Further information comes from some inscribed slabs found in Cerignola [10] that could belong to the bridge. This type of inscribed slabs bore the inscription relating to the work, exalting its completion, and was part of the construction program of the *Via Traiana*. Also in this case, even if we do not have any information on what the original parapet looked like, the metric data relative to the "front" (5 Neapolitan palms, that is 132 cm) corresponds exactly to the height of the slab of Cerignola, letting us imagine that it was set along the balustrade that delimited the passage on the bridge (Fig. 7).

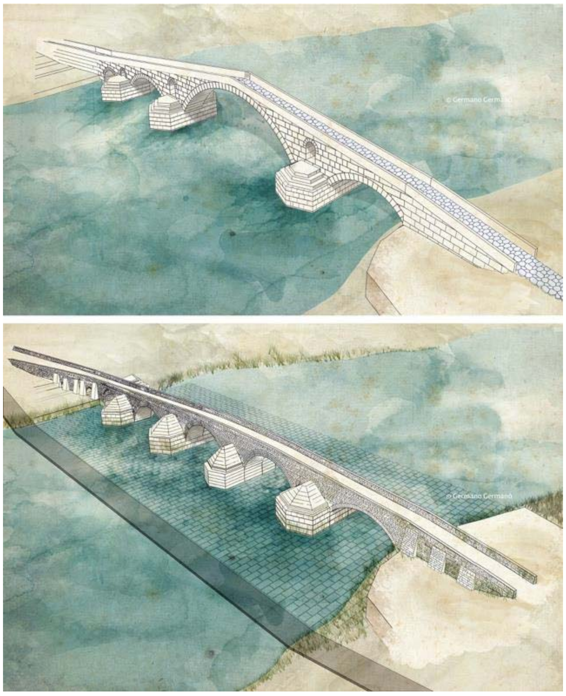

Fig. 7. Illustration of the two main phases: upper, the Roman bridge; lower, the bridge nowadays showing the foundation platea. (elaboration by Germano Germanò)

V. CONCLUSIONS

In a impervious context such as the river one, and challenging due to the shortage of sources and archaeological data, through careful numerical verification and a comparative study of the few but precious data available, metrology has made it possible to formulate reconstruction hypotheses with a high degree of reliability on a monument that has been strongly compromised over the centuries.

Naturally, these hypotheses restrict the field of investigation to a shape and a modular dimension that must be verified later with a precise archaeological study.

Beyond the theories on the exact morphology of the bridge, the research brings to light an architectural reality whose scope has been unfairly underestimated, and which places the bridge back in the history of ancient architecture, counting it among those with a central span among the longest in Roman times (Fig.&.

REFERENCES

[1] R. Cassano, Il ponte sull'Ofanto, in R. Cassano (ed.) "Principi, Imperatori, Vescovi, Duemila anni di Storia a Canosa", Venezia, Marsilio, 1992, pp. 708-711.

[2] G. Ceraudo, Via Gellia: una strada 'fantasma' in Puglia centrale, in "Studi di Antichità" vol.12, Galatina, Congedo, 2008, pp. 187-203.

[3] M. Chelotti, V. Morizio and M. Silvestrini, "Le epigrafi romane di Canosa II", Bari, Edipuglia, 1990.

[4] P. Ieva, La sepultura di Re Boamundo in una inedita brieve descrittione tardo-cinquecentesca, in C.D. Fonseca, P. Ieva (eds.) "Unde boat mundus quanti fuerit Boamundus: Boemondo I di Altavilla, un normanno tra Occidente e Oriente: atti del Convegno internazionale di studio per il IX centenario della morte, Canosa di Puglia, 5-6-7 maggio 2011", Bari, Convegni. Società di storia patria per la Apulia, 2015, p. 301-335.

[5] M. R. Tritto, I restauri settecenteschi del ponte romano di Canosa di Puglia, in L. Bertoldi Lenoci (ed.) "Canosa. Ricerche Storiche 2004", Fasano, Schena Editore, 2005, pp. 71-100.

[6] A. Mazzi, Nota metrologica, in "Archivio Storico Lombardo", Milano, Società Storica Lombarda, 1901, p. 354.

[7] C. Salvati, Misure e pesi nella documentazione storica dell'Italia del Mezzogiorno, Napoli, L'arte tipografica, 1970, pp. 34-35.

[8] E. Lugli, The Making of Measure and the Promise of Sameness, University of Chicago Press, Chicago, 2019, p. 20.

[9] A. Rovida, R. Camassi, P. Gasperini and M. Stucchi (eds.), Italian Parametric Earthquake Catalogue (CPTI11). Istituto Nazionale di Geofisica e Vulcanologia (INGV), Milano, Bologna, 2001, https://doi.org/10.6092/INGV.IT-CPTI11.

[10] G. Ceraudo, A proposito delle lastre iscritte dei ponti della Via Traiana, in "ATTA 22", Roma, L'Erma di Bretschneider, 2013, pp. 143-153.