# The masonry bridges in Southern Italy: vestige to be preserved

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ABSTRACT: A previous work, "The Stone bridges in Southern Italy: from the Roman tradition to the Middle XIX century", presented during the Arch Bridges IV, underlined the connection between bridge construction and street network. With the fall of the Roman Empire and the consequent breaking up of the territory into small free states, road construction was no longer a priority and many suburban bridges were abandoned as well. This survey focuses on the Sannio area. It will take into account the following:

- ancient bridges still on use;
- bridges of Samnite' Age, adapted in the later centuries, nowadays in a marginal rule with respect to the roads net;
- bridges cut off from the road system.

The aim of this paper is to describe some of these structures and thereby propose a cataloguing methodology of structural, technologic and material aspects of masonry bridges. The planned methodology's ultimate purpose is to preserve adequate evidence of this heritage and lay the foundations for its safeguarding in case, future sensibility towards these constructions will not depend exclusively on their utilization.

# 1 INTRODUCTION

Located at about 80 Km N-NW from Naples, the Roccamonfina volcanic pile, extinct in protohistoric era, divides the area in two ambits which differ not only from a geographic but also from a cultural point of view. On the West side, a coast, full of natural ports with a rich plain on the back, was inhabited before Greek colonization, by the autochthonous people of Aurunci, Sidicini and Oschi; the East side, a mountainous highland, was the reign of the Samnite, shepherd warrior people that, for transhumance needs, frequently invaded the lower Volturno and Garigliano plains. Their cattle tracks were the first route sketches. The construction of a wide road network began after the Roman conquest of the inner lands, it was accomplished by connecting the *Via Appia* on the West and the *Via Latina* on the East thanks to branch lines and side streets, which linked the oldest cities with the new founded ones. The Consular roads had their significant completion in bridges: no longer ford or precarious wooden structures but stable masonry bridges.

With the barbaric invasions and the fall of the Roman Empire, the territorial structure radically changed: the *Via Appia* lost the *Regina viarum* role, the coastal Greek colonies declined and the flight to the country caused a fortification process of which the transformation of the *villae rusticae* into fortified farms was a first example. All that, plus the plane at the *Clanius* river's mouth swamping and the Saracen pirate incursions, signed the definitive end of an era.

Just a narrow area close to Naples continued to be formally allied to Byzantium, while the whole inner territory was of complete appanage of the Longobards since 568 A.C. The great

roman roads were seen as means of invasion: the Longobard arms came through Sulmona and the *Via Valeria* to conquer the Campania Region, in order to avoid the *Via Appia*, where they could be intercepted by the Frankish who enforced their guardianship over the papacy.

With the dismantling of Roman power, a different territorial organization rose: fortified villages and castles on top of hills and mountains, for the surveillance of ancient roads; on the East side the road network seems to increase, but they really were just tortuous mountain routes, paths not streets, dodging around the cities. Bridges are the first constructions to pay the consequences of this "syndrome of siege and invasion": they were often completely destroyed or modified by the demolition of the arches and replaced by wooden planks which were easy to be dismantled.



Figure 1 Main connections

Subsequent conquests, by the Normans and Swabians first and the Angevins later, preferred Naples as the Reign's Capital, historically laying the bases for the enormous development of the Neapolitan urban structure, to the detriment of inner cities and of the whole Southern Italy. Roads and bridges were still helpful but just for victual transportation to the cities, while much of the trades occurred by sea. Only the *Via Appia-Traiana* received some maintenance, because of its fundamental role of grain route between the Puglia Region and Naples. Finally, in the 16th and 17th century, the Regi Lagni construction took place with the consequent drainage of the *Clanius* swamps and the *Via Appia*'s partial restoration. Another century would have to go by for a wide re-establishment program of ancient routes and construction of new tracks to begin under the reign of Charles 3rd of Bourbon.

Figure 1 is a sketch synthesizing the evolution and transformation of the main connections between the territorial rising elements. Nowadays the remains of the bridges, some abandoned, some others still in use, are signs of the considerable changes in the road network and of the evolution of construction techniques.

Among the evidence, three typical examples have been chosen: the Quinto Fabio Massimo Bridge near Faicchio, still in use as a pedestrian bridge, which bares the history of constructive techniques, from the ancient Samnites to the Roman, Medieval and more recent ones; the Hannibal Bridge on the Volturno river, placed on an important route, which was destroyed and rebuilt many times; last but not least, the so called "Sfunnato" Bridge on the Savone river, abandoned only few decades ago by the construction of a new link road.

## 2 STUDY CASES

#### 2.1 The Fabio Massimo' Bridge on the Titerno river, near Faicchio

The Fabio Massimo bridge, so called in memory of the Roman leader who defeated the Samnites after 70 years of war, represents an interesting example of the persistence through millennia of an important route. It was probably located on one of the important transversal links of the *Via Latina* or on the *Via Latina* itself, as asserted by Galliazzo [1995]. Because of the changes suffered during the centuries, the bridge represents a catalogue of the constructive techniques' development (Fig. 2). Nowadays it has three arcades, the larger of which is placed on the Titerno river gorge. The foundations are stably anchored to the rock banks and exhibit a polygonal block structure which is typical of the last period of the Samnite independence and similar to that of the fortified stronghold on the Acero Mountain. The big angular blocks are perfectly jointed on the faces and well connected, especially on the upstream façade in order to withstand the rush of waters.



Figure 2 Fabio Massimo' Bridge

The *opus incertum* and *opus quasi reticulatum* of the central arcade tympanum date back to the Roman period (1st-2nd century B.C.). This arcade of 13m span and 4,10 m rise has *bipedales* double ring face arches and a cast masonry vault made of little limestone *caementa* joined by abundant mortar, a technique of the Adrian period. During the Medieval era, the bridge was damaged by a major flood and was then restored thanks to the integration of calcareous stones in the arched lintels of the main and smaller arcades (4,10 m span) and probably also to the reduction of the carriageway. At the end of the 19th century the roadway was leveled and a new little arcade on the riverside was built, while the parapet reconstruction dates back to the 20th century. Nowadays the bridge is not suitable for vehicles but it is perfectly suitable for pedestrian use.

#### 2.2 The Hannibal bridge on the Volturno river, near Santa Maria Capua Vetere

Today's structure stands on the ruins of an ancient Roman bridge, probably destroyed by Hannibal for strategic reasons. In spite of the lack of documentation, a good reconstruction of the original bridge has been accomplished thanks to the remains (the abutments, the first two arcades on the left and the intermediate piers' submerged foundations) brought to light before the successive edifications: it was a bridge with six arches of variable span and a global length of 100,00 m (Fig.3). The plank width was 7.15 m and the piers had cutwaters with triangular prismatic base forestarlings. The piers' and abutments' masonry had a core with parallel courses of tuff, connected by mortar of local pozzolana and loamy lime extracted from the rocks of the lo-

cal mountains. The barrel vaults were built with five parallel alternate fields: three of bricks and two of tuff. The entire structure was covered by a brick curtain.



Figure 3 Hannibal' Bridge remains (from Sasso Memoir)

In 1868 the need to create a better link between the two Volturno banks, until then connected by a bridge of boats, motivated a first bridge reconstruction planned by the Eng. Pastore di Capua. The project foresaw the use and partial modification of the existing piers, but the will to regularize the spans didn't allow for optimum employment of the old foundations. In 1867, before the work was entirely accomplished, the river flood destroyed the intermediate piers. In 1868 the project was assigned to Eng. Giustino Fiocca. Due to the presence of considerable waste in the riverbed the central piers could not be rebuilt. The designer chose a single depressed arcade between the remaining piers, with a span of 55,00 m, and a connection to the abutments by annular vaults.



Figure 4 Fiocca' project of the Hannibal' Bridge (from Sasso memoir)

See the memoir by Sasso [1871], Fiocca's collaborator, for a better knowledge of the structural solutions, the building procedures, the stability checks, and the mechanical and physical material properties. This paper summarizes only the special technique solutions which make the reconstruction project an interesting one:

- The bridge width was reduced to 6,61m in order to unload the piers that in the Pastore di Capua plan jutted out from the perimeter of the Roman foundation.
- The gables were lightened by tuff annular arches of variable radius and the nonconventional solution in the Campania region was camouflaged by a brick curtain wall.
- The big annular vaults between the piers and the abutments were left open to allow a further outlet to the water flood.
- Different types of pozzolanic mortar were used to allow the complete and simultaneous centering dismantling, once all the elements had fully united.

Unfortunately, during the last World War the bridge was destroyed. The need to connect the two banks of the river led to the bridge's reconstruction which was accomplished by reusing the big annular vaults and connecting them by a concrete arcade.

#### 2.3 The "Sfunnato" bridge on Savone river, near Rocchetta e Croce

Among the vestiges of the Roman territorial policy after the "Campania Felix" conquest (Fig. 5.a), the Valdassano bridge-viaduct is worthy of special attention. It stands over the Savone erosive valley, on a "diverticulum" of the Via Latina connecting the towns of Teanum Sidicinum and Cales to the ager alifanus. According to Carroccia's hypothesis [Carroccia, 1989], it is the same route sketched in the Peutinger's table in order to link Teanum Sidicinum and Telesia. The area, rich in archaeological evidence, dates back to the 7th and 6th centuries B.C. and probably had an important role in the land's economy, even before the Roman occupation. This road confirms the Roman custom of improving the connection network in subject countries by adding significant bridges to the routes every time that solution, regardless of expenses, provided a more direct link. The increased strategic importance of the territory that followed the Roman conquest perhaps explains the carrying out of such massive masonry work along a route that today is no doubt secondary: even the carriageway's 8.5 m width is not consistent with the usual 6 m width found in the extra urban bridge tradition.



Figure 5.a de Laurentiis map (On line: www.ulixes.it)



Unfortunately, only the local communities care for the monument; in fact, even in Galliazzo's work this well preserved viaduct isn't quoted and the bit of information available comes from oral traditions more than archaeological studies or archive researches. It is necessary to point out that it has been only in recent times that a significant, but incomplete, archaeological campaign has brought to light many objects baring evidence for the whole area's strategic importance.

Nowadays, the bridge is out of the main track because of a detour of the Valdassano and Riardo connection accomplished after the Land Office mapping (Fig.5.b) completed at the beginning of the last century.

In the Middle Ages the bridge was still in good conditions and, according to Riccardo di San Germano [Caiazza, 1995], in 1229, the Emperor Federicus II of Swabia crossed it. It was probably used until the Second World War. Today the monument is completely abandoned and destined to collapse (Fig.6).



Figure 6 Front of the "Sfunnato" Bridge (from Caiazza)

In fact, the actual bridge (Fig.7.a) consists of four round partially buried arcades, with different spans and pier widths. The bays are connected to the main route by long wing walls on the southern side; the carriageway has an average 9.33% slant. The last northern arcade, which stands on the Savone river bed, has partially collapsed and the front arches are strongly deformed (Fig.7.b). The core type masonry has a texture in *opus incertum* with coarse parallelepipedal local *cementa* of various sizes. The masonry inner portion of the piers and of the vault (Fig.8.a) up to the reins is realized by small grey tuff blocks, joined by pozzolanic mortar; the upper vault, from the lodging of the suspended wood scaffolds upwards, is in *opus cementicium*. The 80 cm high front arches are made of highly refined travertine slabs, 20-30 cm thick, joined by a bit of mortar and arranged alternatively by header and stretcher to assure a better toothing with the back cementitious vault. The same "L" (Fig.8.b) solution is adopted for the piers, while the covering in travertine slabs, running along the whole width, is visible only in the arcade's lower part on the Savone river.



Figure 7.a Overview of the bridge



On the southern arcades, and corresponding to the arches' crowns, there are two stone gargoyles of about 30 cm under the still existing road superstructure. The latter, made of calcareous elements of medium sizes, is probably not the original one; the *opus incertum* face portions between the southern arcades, constituted by grey tuff elements of medium size, were added during later repair works. It is difficult to date the bridge; the most reliable methods are the carbon-14, which requires organic materials and the thermoluminescence on fictile materials. Unfortunately, the viaduct lacks both organic and fictile materials and historical records are yet to be found. Given the need to consolidate the bridge's unsafe parts and bring the entire structure to light, a careful working-face stratigraphy and archaeological recovery should lead to an indirect dating. At present, considering all the risks of a typological-constructive analysis, we can ascribe the bridge construction to the period between the end of the Punic wars and the first century B.C.



Figure 8.a Detail of vault masonry

8.b Travertine slabs of the pier

## **3** CATALOGUING PROGRAM

The complex territory history summarized in the introduction shows that the three described bridges are single examples of a more complex heritage existing in the area: many monuments have been already benn studied by previous researches (Ronaco bridge, Leproso bridge, Carolino aqueduct, etc.) [Bove, 2004; Colletta, 1989].

After many years of complete indifference, there has been growing awareness that masonry bridges are important elements of the Italian cultural heritage, because they are architectural monuments and because they are proof of theoretical knowledge and building ability. Their safeguard is often at risk: their renewal is difficult, but rarely impossible, and depends on functional adaptation and hydraulic compatibility. For these reasons and because of the early  $20^{\rm th}$  century technical education which was concerned with the iron and concrete structures more than with the masonry ones, demolition has been preferred, therefore causing the loss of many specimens and creating considerable gaps in the study of the constructive techniques' evolution.

Such an articulate reality and its interpretation leads to the proposal of a systematic cataloguing program of the known vestiges: articulate and consistent information would be at hand for those who are interested in knowing, preserving and restoring the bridges; this kind of data base would provide the guidelines for the adaptation, casting of or demolition of each structure. Subsequent repair works would be guided not only by technical rules and performance effectiveness, but also by the cultural, architectonic and constructive value of the monument. Moreover, if it was necessary to demolish a bridge, there would still be substantial and documented traces, easy to be attained without long searches in libraries or archives.

The file's structure includes increasing levels of knowledge and is more effective in digital form where links to the specific thematic pages can be easily accessed by scholars, professionals or interested individuals. The first level is developed on a single page and organized in fields which summarize the main data taken from the specific literature and a preliminary relief of the building.

The first field provides the historical and geographical contextualization and is divided in three modules: "name and function", "dating, restoration and sources", "location". The module "dating, restoration and sources" has a second level with the listing of all the criteria used for bridge dating (historical documentation, analogy, chemical and physical analysis) and the accurate description of the restoration project listed in the first level. The same level contains references regarding historical sources and meaningful iconographic documentation. The third level should provide digitalized historical and technique documentation.

The following ten fields –"vaults", "abutments", "piers", "cutwaters", "foundations", "tympanum", "crowing", "roadway", "access", "riverbed"- provide detailed descriptions of the bridge's main components and every field is divided in three modules as well.

The first one –"shape and geometry"- summarizes the relief's data, and the related drawings are in the second level. The second and third modules –"constructive techniques" and "materials"- offer an overview of all the information (masonry texture, assembling methods, technical solutions and materials) concerning each element. The following level includes the detailed drawings plus the references and links to other bridge <u>files</u> with the same constructive techniques and/or material listings. A further level, essentially technical, can concern the documentation regarding experimental tests or theoretical modelling, in which the material's mechanical characteristics or the element's structural efficiency have been tested. Eventually, essays on the geotechnical structure can be included in this technical level.

An application of the described cataloguing program to one of the analyzed bridges will be shown in the oral presentation.

#### 4 CONCLUSIONS

Three significant bridges have been described in this paper by pointing out their differences in time of construction, the changes they underwent, and their relationships with old and new road networks. The aim was to highlight the rich heritage of a not very well-known area and point to the need to preserve its vestiges. Nevertheless, the cataloguing system proposal is the main purpose of this research and its final goal is to build a "virtual museum" which preserve the memory of masonry bridges and hand on all related artistic inheritance and knowledge. The future steps will be extensive studies on the adopted technical solutions, on the employed materials' mechanical-physical properties and on theoretical models. Hopefully Corporations and Institutions devoted to the Italian historical inheritance guardianship will want to compensate for decennia of carelessness.

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