

VERNACULAR HERITAGE AND EARTHEN ARCHITECTURE

CONTRIBUTIONS FOR SUSTAINABLE DEVELOPMENT

EDITORS: MARIANA CORREIA, GILBERTO CARLOS & SANDRA ROCHA

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Vernacular Heritage and Earthen Architecture: Contributions for Sustainable Development

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Watermills and weirs from the Ave River – an inter-municipality heritage value

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SUMMARY: From the study of the heritage constituted by a set of watermills and weirs along the Ave river, from the source to the mouth, we intend to do a reflection based on five points: 1 - Locate and characterize geographically the Ave river, and make a brief historical background of its importance to the region; 2 - Transmitting certain factors and experiences related to the research process that emerge unexpectedly and eventually characterize the methodology; 3 - Characterize the watermills and weirs from a territorial, architectural, constructive and technological vision; 4 - Analyze a case study of safeguarding, preservation and enhancement of the molinological heritage; 5 - Provide a way for the safeguarding, preservation and enhancement of watermills and weirs as a vehicle for inter-municipality developing.

1 BRIEF OVERVIEW OF THE OBJECT

1.1 *Geographic*

At the northwest of the Iberian Peninsula, mainland Portugal, on the border between the regions of Douro Litoral and Minho is located the Ave River. It belongs to the Territorial Unit NUT III and integrates the geographical framework of the major rivers of Portugal with the particularity of being exclusively Portuguese. Rises in the hills of Cabrera, in Vieira do Minho, and runs towards Northeast / Southwest approximately 100kms to empty into the Atlantic Ocean, in the municipality of Vila do Conde. Its course covers seven municipalities: Vieira do Minho, Póvoa de Lanhoso, Guimarães, Vila Nova de Famalicão, Santo Tirso, Trofa and Vila do Conde. It's characterized by three distinct units related to its geography: the 'alto Ave' corresponds to the first 20Kms of the course and has steep slopes ranging between 400m and 1250m altitude, the '*medio Ave*' is roughly 20Kms to the intermediate course and has slopes ranging between 400m and 150m above sea level; Finally, the '*baixo Ave*' corresponds to the remaining length of the course to the mouth of about 60kms, has gentle slopes ranging between 0m and 150m altitude, forming a plain where the river widens significantly and the water runs smoothly and even to still in its alluvial bed.

1.2 *Historical, social and economic*

The Ave river was a vital geographic element for human settlement in the territory, since the Iron Age to the heavy industrialization of the twentieth cen-

ture. Between these two periods Ave river represented a fundamental support to the agricultural activity in the region. With the evolution of agriculture associated with traditional technology man was creating utensils, gadgets and mechanisms that allowed its attachment near the fertile and cultivable valleys. Gradually it was built a landscape marked by widespread polyculture, which characterizes and distinguishes the region. The cultivation of vines and cereals - corn and rye - were the predominant type of planting contributing to a long tradition of bread and wine, always present in the diet of the population. The importance of cereal in the region stimulated the construction of numerous mills and watermills along the Ave river course and its tributaries. The farm house was complemented by the silo, the barn floor, the dry and the grain store that allowed in a self sustainable progress of the cycle of bread.

From the mid-nineteenth century due to a number of socio-economic factors there were changes in the habits of livelihood, production and consumption. Agriculture became a secondary activity and during the twentieth century industrial activity has occupied a prominent place in the region. With the progress of the textile the Ave river suffered intense pollution that contributed to the separation of the population from the river. In parallel, craft activities, either in grinding or in the manufacture of linen and wool production, developed by the watermills in the Ave river, met strong opposition and competition with the industry, which triggered an unequal struggle in production and trade of flour and clothing. Consequence of this set of factors the watermills and weirs

went into decline leading to ruin countless copies. Today this heritage is the 'memory' of intense activity and prosperous developed so self sustainable and in perfect balance with nature. Besides this precious symbiosis between man and nature it was lost the knowledge about traditional construction techniques, as well as the knowledge, art and ingenuity used in the maintenance of watermills and their weirs that millers and craftsmen for centuries preserved generation after generation.

Today we see this paradigm changing. The Ave river initiated a process of natural regeneration visible by the fauna and flora. Contribution to this fact: the crisis and the collapse of the textile industry, the construction of a network of domestic and industrial sanitation, and finally the recent activation of a set of Stations Wastewater Treatment deployed along the river Ave. Consequence of these actions the population has been searching the river again and regain some of the 'memories' lost in recent years.

2 RESEARCH METHODOLOGY

2.1 *Identity: recognize to valorise*

The lack of contact between the population and the river, in recent decades, along with the decay of heritage, it originated an identity void, either in older generation that still remembers the activities in the river or in the younger generations who do not know the river or its associated heritage inactive for decades. We can anticipate that we are moving into an irretrievable cultural loss. Given that fact, in parallel with the research development were conducted outreach activities involving the local community, owners of mills, millers, local Associations, Schools and Municipalities. These initiatives allowed revive the 'memory' and at the same time re-establish links between past and present. The children had the opportunity to visit the only mill capable of grinding the Ave river which still preserves the wit, according to the traditional building techniques. The miller opened the doors of the Azenha de Bairros for the group of children from the school EB1 de Bairros who were able to learn: through the cereal we make the flour to produce bread, that they eat daily. The next day they made drawings which portrayed their stored memories, from the visit of the Azenha de Bairros watermill.

2.2 *The condition as a vehicle of thought*

If in one hand, from a pre-defined strategy can convey a certain stability for research, on the other, to adapt this strategy to 'circumstances' of object can trigger a surprising and revealing process, which leads to unexpected results for research. When we had set the initial plan the aim was to study only the watermills of the left bank of the Ave river, located

in the municipality of Trofa. With the progress of the study we verified that the watermills generally were deployed in pairs, both on left and right bank of the river. From this observation, the result of 'circumstances' surrounding the subject, we chose to study in parallel the watermill on the right bank, located in the municipality of Trofa and the watermill on the left bank, located in the municipality of Vila Nova de Famalicao. As we studied the watermill on the left bank historical, architectural and anthropological information came up regarding the watermill on the right bank and vice versa. This decision with direct implications on the size of the study proved to be fundamental to understand the core unit, formed by the two watermills, strongly related to the land and to the water territory.

3 WATERMILLS AND WEIRS OF THE AVE RIVER

3.1 *Relationship with the terrestrial and aquatic territory*

When analyzing the watermills and weirs we must always consider their relationship with the territory water and land. Looking at the Ave river along its 100kms we realize that there are several cores that stand-out, set by two watermills joined by a weir, often distributed along the river, at a pace and precise distance from the source to the mouth. Between the sixteenth and seventeenth centuries, Duarte Nunes de Leão, "(...) alluding to the patience of those who wish to tell the watermills of the Ave river, writes: And continuing to its mouth at sea, told him, (Rio Ave) 502 watermills and windmills, nine oil mills and a fulling mill." (Oliveira, 1941: 95) This steady pace of core implementation along the river formed a "plurinuclear diffuse system" (Matos, 2011:162), with a secular relationship with the territory.



Figure 1. Identification in the ortophotomap of the 'plurinuclear diffuse system' between Trofa and Vila Nova de Famalicao municipalities. Base map source: Department of Urban Affairs and Planning C. M. Trofa.

The low Ave since Roman times is an area of intense intercity transit due to important trade relationship between the cities of Oporto - Braga, Oporto - Barcelos and Oporto - Guimarães. Even today we can see that the primitive paths, oriented in a north-south, located at opposite sides of the Ave river are interconnected by its nuclei. In this sense, the watermills and weirs served as liaison between the margins routes by the several villages. In addition to the autonomous crossing there were numerous "cross river boats" that were quite requested by the population and travelers. Anchored to the watermills they were operated by the miller or by the municipal authorities. *"The historic wayfarers with Braga goal, to reach the left bank of the Ave river, boarding into the barge, that could fit 12 people, and the miller in return for some "reais", transported to the right bank of that river with the momentum of a four meters eucalyptus, resting on its bed."*(Portela: 2004: 76-77).

Besides the direct influence on the mesh paths, the aim of the 'system' built along the river was to explore the water resources in a balanced and fair, of its use, conduction and control of flow rates. This factor implies compliance with certain rules agreed between millers and farmers, with the aim of allowing sustainable use of water resources, in carrying out various activities. In addition to the agreement between the millers and farmers there was a pact between all millers installed along the Ave river. The permanent contact between them was essential for the proper construction and maintenance of weirs that followed certain constructive standards, in order to the safeguarding and the balanced functioning of the whole water 'system'.

3.2 Architectural and constructive characterization

The Ave river watermills are constructions of popular character with construction specificities related with its function and the conditions of the place, marked by the constant contact with water. The construction materials used are stone, wood and iron. The type of material is changing according to the geographical location, ie in certain areas it is used only shale, elsewhere we find the alternate use of the shale and granite or exclusive use of granite. The spatial organization of the watermills has varied over time. It began to be composed only of two floors: the cellar and ground floor. From mid-twentieth century, given the need to increase the productivity in many cases it was extended another floor, corresponding to the 1st floor. The cellar we might call a technical area of the building and is the space where we can find the system of the grinding gears. The access to this floor is done through a trap door located on the wooden floor on the ground level.

It is only used when operating the maintenance and tuning of the mill. In the ground-floor we can find the millstones designed to receive the grain and turn it into flour. The number of millstones was changing over time, in relation to the productive needs. When it was possible regarding the conditions of the place the miller added one or two vertical wheels. With that modification they start to have four or five driving wheels and sometimes, *"(...) at the Ave, we could find facilities with 10, 12 or even 15 millstones pairs."* (Oliveira: 1941: 95). From the ground-floor level we can access directly to the river, to the weir and also to the bases where were located the hydraulic wheels. Sometimes, incorporated in those bases there were macerate mills for the linen, fishing systems and a cross river boat. The 1st floor is an open space with few partitions dedicated for storing the rain, flour and maintenance tools. It was also destined as a sleeping place for the miller and also to keep its personal belongings.

From an architectural point of view the watermills have a specific characteristic related with their location – the water. It is frequent see them lay down completely on the water, like a fluvial island, exposed to the permanent erosion and violence of the floods. In such cases, they have a device similar to the medieval bridges columns, named by breakwater. A big massive of well organized stones *"(...) like a big ship prow, heading to the stream. When the floods come, the water meets the big keel and the Watermill stays unharmed"*, (Dias, 1993: 207). This aspect represents a factor of morphologic variation of the watermill. In that sense we find in the Ave river several types of breakwater: 1) round and non-massif, 2) round and massif; 3) massif and sharp-cornered 4) without breakwater. This relation varies, mostly according to the river characteristics, the water flow and the river stream. The architectural, constructive and technologic diversity reveals that we have a typology with unique characteristics that meets a set of patrimonial values with high disciplinary interest.

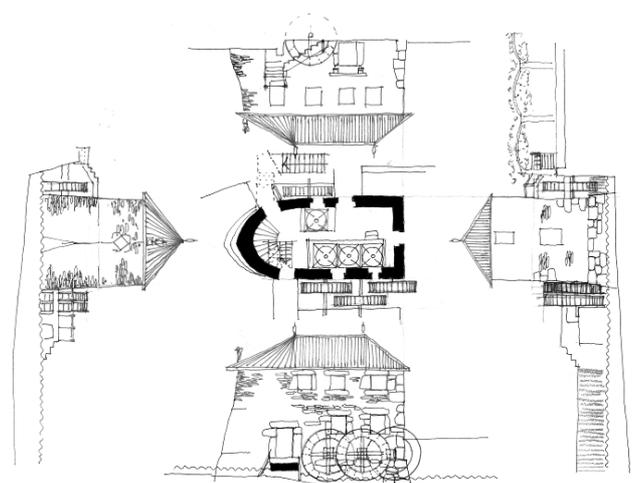


Figure 2. Survey design with the reconstitution of the grinding system of the Bairros watermill - Trofa. Source: R. Bruno Matos

3.3 Traditional technology

The key feature that distinguishes the watermill from other water operating systems is its technology. Result of cultural miscegenation between Romans and Muslims emerged a versatile and multifunctional mechanical system known in the Iberian Peninsula as – 'azenha'. The term 'azenha' (in Portugal), or 'aceña' (in Spain), a unique Iberian vocabulary used to define a specific type of watermill with vertical wheel. While in other European countries the same type of mill is simply named as Mill with Vertical Wheel or Roman Mill. Are we facing a system specific to the Iberian Peninsula? In the Aves watermills the constructive constitution of the hydraulic vertical wheel reveals the influence of two cultures. If we analyze the wheel drawn by Vitruvius we can see that it has 'tabs' radially distributed, individually linked to the horizontal axis by a horizontal beam. On the other hand, the wheel used on the Aves watermills are constituted by 'feathers' distributed radially interconnected by two perimetral 'flaps'. This constructive system approaches to the ones used in the 'norias for lifting water', of Muslim origin. "*Las técnicas hidráulicas clásicas difundidas e intensificadas por los musulmanes en las tierras hispanas conquistadas a partir del siglo XIII y difundidas por Europa, aparecen constatadas en los textos escritos de geógrafos islamitas. Al-Udri registra que «en el río de Tudmir hay norias que riegan sus cosechas; las acequias que arrancan de él empiezan en Alcantarilla y llegan a las tierras de las gentes de la ciudad de Murcia (...)*»", (Carrillo, 1993:18).

The vertical wheel of the Bairros watermill from Trofa has 4,20m of diameter and 0,30m thick. In between it has two big parallel arcs, named by 'flaps' and are structured by two perpendicular diametric 'arms'. However, the Ave watermills follow the Vitruvian principle with a slight difference: the cogwheel was replaced by two pieces of extreme importance to the system – the 'gear' and the 'gear-wheel'. Those two parts allowed transforming the vertical rotating movement into a horizontal rotating movement and at the same time gear down the rotation speed. This gear detail makes the watermills one of the most recognized milling systems in history, due to its multi-functionality and efficiency. Its versatile technology allowed efficiently execute various activities, such as grinding grain, flattening wool, softening linen, wood sawing, crushing the olives, papermaking, gunpowder manufacture, irrigate fields, among others.

4 SAFEGUARD, PRESERVE AND ENHANCE THE HERITAGE

In the present identified area which includes the course of the Ave river over 26Km between the

municipalities of Vila Nova de Famalicão, Trofa we can see that there are 45 watermills and 24 weirs. Within this universe: 17 are in ruins; 8 are vacant; 7 disappeared due to the floods; 4 were demolished by man; 4 were transformed into temporary housing; 1 transformed into a mini-hydro; 1 transformed into a leisure space; 1 transformed into a bar / nightclub, 1 transformed into an events room, and finally, only one preserves the traditional grinding able to produce flour. In no case was there any concern for safeguarding, preservation and promotion of cultural heritage, and the interventions over the past decade did not respect the identity, nor the traditional construction systems.

In parallel to the analysis of the study object - the Aves watermills - we perform a case study of intervention in the molinological heritage. Among the selected cases we chose to analyze the samples with similar characteristics to the study object regarding the water architectural and technological aspects. From the critical analysis of the case studies of intervention in the molinological heritage we highlight the program, methodology and work process that involves in this kind of specific rehabilitation, thus we consider the advantages and disadvantages of the process. In that sense we decided to analyze the intervention carried out in the Leiria's Paper Mill, located on the Roberto Ivens street, on the left bank of the Lis river the source of Santo Agostinhos convent.

The Leiria Paper Mill is a peculiar example of relevant interest for the study of molinological heritage. Based on a popular architecture, gathers in a single building the two systems based on the traditional hydraulic technology - the vertical wheel - 'watermill' - and horizontal wheel - "caster mill". Furthermore, in its history has generated various traditional activities such as grinding cereals, paper manufacturing, oil production, as well as support of agricultural irrigation. These diverse historical aspects, architectural and anthropological are common characteristics of the study object - the Ave watermills.

4.1 Method, Project and Work - Álvaro Siza

In 2003 when the project intervention in the Leiria Paper Mill started the building was in an advanced state of degradation. Only resisted with difficulty and had poor conditions to grind the grain. The remainder of the building was in ruins, with no ceilings, no frames and full of vegetation. Traditional systems for paper manufacture and oil production had disappeared.

Based on the historical and archaeological study of the evolution of the mill throughout 'time', the survey of the current state of pre-existence, and the 'know-how' by the miller Manuel Meneses, the architect Álvaro Siza developed an intervention

project for the Leiria Paper Mill. The project program followed these general objectives: *"Preserving the cultural heritage of the city of Leiria; - Promote the development and promotion of technical and industrial heritage; - Recovering a paper mill and a cereal mill; - Using the techniques and traditional methods in the production of the paper; - Produce paper for multiple uses, including Arts; - Create a center for educational and cultural resources; - offer new cultural resources and tourism for the city, the region and the country; - Establish a technological bridge between past and present, always with a view to a future with more innovation and wealth."* (Nabais, 2009: 53)

The proposal by the architect Álvaro Siza has demonstrated an exemplary interpretation of the programmatic goals, and above all, a perfect awareness of values inherent to the molinological heritage related to the history, the identity, the place, the function and the traditional construction techniques, either in the architectural component or technology. The proposed intervention foresees *"(...) the recovery of the existing building, building a new body and the treatment and rehabilitation of adjacent outdoor spaces."* (Siza, 2005:1).

The recovery of the existing building required a deep constructive rehabilitation work due its advanced state of degradation. This factor led to the understanding of the mill's morphologic evolution throughout its history. Thereafter Álvaro Siza proposed three new functions to the existing building without colliding with the identity of the mill. The production of paper requires a larger room, warehouse, a toilet and a management area. *"We think that the current bigger room was the original room for the production of paper, in the fifteenth century, as we think that this space will be suitable for the replacement of all the needed pieces for the production of paper"*, (Carvalho, 2005:1). In this room it is possible to know the process of papermaking and printing with manual tools such as hammers, presses, vats, drying and view the operation of the gauges using hydropower. In this room we can also see an archaeological find - a 'ewer'- which depicts the memory related to the production of the olive oil.

The grain milling comprises two areas. One of the areas *"(...) will operate autonomously and is designed for the observation of the mills, (...)"* (Siza, 2005:1), in all its dimensions, since the gears located on the cellar, passing through the double grindstones, and ending in the hopper where it is introduced the cereal. In this room it is possible to understand the distinction between grinding system of vertical wheel and the grinding system of horizontal wheel. In the 'cereals room' it was restored the original production capacity, with four pairs of millstones: a couple of 'alveiras' and three couples 'negreiras' *"(...) and all the hydraulic and*

technologic structures, so it can be possible see the traditional grain milling and know all the stages of this art"(Carvalho, 2005:1) In the rehabilitation process of traditional grinding systems Álvaro Siza resorted to the 'know-how' of the Miller Manuel Meneses. From the sharing of this knowledge between Architect / Miller it was possible to preserve traditional techniques and materials of the various grinding mills. *"In the area of cereal it will be possible to observe the miller in his daily activity, producing corn flour and wheat and doing the daily maintenance of their vital structures"*, (Carvalho, 2005:1). The grain mill room also has a storeroom and a toilet upstairs.

The coffee with terrace is *"(...) installed in the old kitchen and is supported by a storage room and serves a terrace along the river. The terrace has access from the building interior and also from the exterior (in the top east) through the door and stairs."* (Siza 2005:1).

The construction of the new body is designed to the house reception, the exhibition space for the 'industrial memory' and public toilets divided by sex and for people with disabilities. This new space restores the volumetry of the Lagoa's watermill, once a mill in ruins before the intervention. It adds a new built volume according to the traditional techniques and similar materials similar to the existing buildings. The roof is inclined with tiles, the masonry in stones plastered with lime, parquet flooring and wooden window frames. This new volume reveals an implantation that establishes a close relationship with the preexisting set. Their presence delivers a constructive evolution that starts east with the grinding zone, followed by a space for papermaking and ends with the exhibition space comprising the new volume. At the same time it indicates the main entrance creating a small space / courtyard, paved in Portuguese cobblestone, which makes the transition between the street, the museum space and the access to the river.

Regarding the redevelopment of the outdoor spaces *"(...) they include the reconversion of the sidewalk and parking on the South and East sides of the building"* (Siza, 2005:2). In the remaining spaces Álvaro Siza intervenes surgically relating the 'memory' with the contemporary requirements, keeping outdoor areas and the same appearance of the set. The terrace of the cafeteria located on the east side shows it well. It has a trellis that protects the heavily frequented terrace, near the entrance to the mills or along the access path. Álvaro Siza proposes a terrace *"(...) covered by a tendone supported by columns, steel profiles and wire"* (Siza, 2005:2). With another record he resolves to qualify a small access bridge to the river, portrayed in engravings and old photographs, in which he proposes a new contemporary using steel, wood and local stone. He brings back the 'wheel to raise water'

and gives it a new meaning related to historical references once established in the convent of Santo Agostinho. The 'wheel to raise water' used in the sixteenth century to feed the garden of the Convent, started to feed a small fountain in the garden located near the main entrance and also a teaching garden located outside between the current Environmental Interpretation Center and Paper Mill. In the exterior the theme of water cuts across all interventions and from the terrace we can see and hear the water in the weir, the new bridge hangs over the water channel in constant motion, and the 'wheel to raise water' represents a tribute to the water in the human life.

5 FINAL NOTES

From the previous reflection we consider that the Ave River is a tripartite geographical unit that varies according to the morphology, geology and hydrology. The river and its heritage represented and still represent a fundamental support for the social, economic and cultural evolution of the region. To understand the watermills of Ave we have examined the object in two scales: macro - geography and territory, and micro - architecture, construction and technology. The case study of the Leiria Paper Mill rehabilitation showed us that it is possible to adapt new practices and programs for safeguarding, preserving and enhancing the molinological heritage. To briefly summarise, we find that associated to the Ave River's course there is a set of watermills that hold values of tangible and intangible assets related with memory, identity, tradition, technology and culture. Intervention can mean a new use: education, energy, environmental or 'memory', such as the Leiria Paper Mill. But it can also consolidate a ruin, as a document of 'time' and of history, part of a thematic route: cultural, sporting, recreational or bathing. Thus, - river and heritage - can be - lever and anchor - for the inter-municipality development of the Ave.

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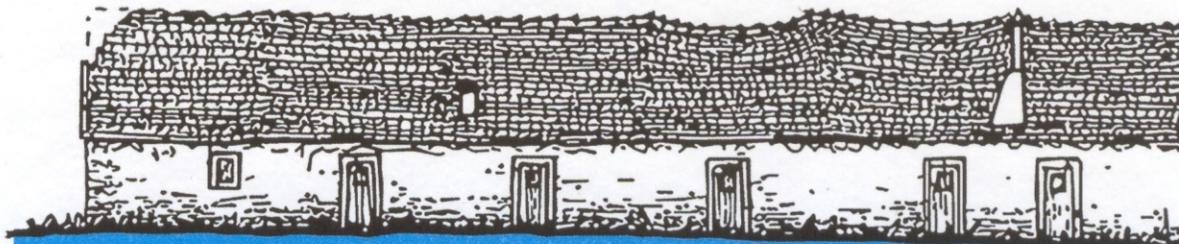
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In a continuously changing world, there has been a growing interest in the protection of vernacular heritage and earthen architecture. The need to protect and enhance this fragile heritage via intelligent responses to threats from nature and the environment has become evident.

Historically, vernacular heritage research focussed on philosophical aspects and surveys, while earthen architecture studies emphasized earthen material and construction techniques. However, for these particular forms of heritage to survive, academic research had to shift its focus, so as to respond to new challenges. **Vernacular Heritage and Earthen Architecture** gathers contributions of key international researchers from 50 countries, and covers a wide variety of topics:

- Cultural heritage and building cultures
- Materials and construction techniques
- Territory and environmental adaptation
- Energy efficiency and sustainable design
- Natural hazards and risk mitigation
- Education and research focus

Vernacular Heritage & Earthen Architecture: Contributions for Sustainable Development discusses the threats that vernacular and earthen heritage are facing, and reflects on their important contribution to sustainable development. The book will prove to be a valuable source of information for academics, researchers and professionals in the fields of vernacular heritage, conservation, architecture, civil engineering and construction, and can be used as a reference text for undergraduate and post-graduate courses in vernacular heritage and earthen architecture.



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