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THE SASSI OF MATERA AS THE OLDEST BIOCLIMATIC ARCHITECTURE MODEL.

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Keywords: Bioclimatic, Energy, Sustainability, "Organic" architecture.

Abstract *The Sassi of Matera are the oldest example of bioclimatic architecture in the world, thanks to its materials, its typological and functional characteristics, but above all thanks to techniques and technologies. The calcareous rock or tuff characterizes the whole architecture of the Sassi, caved into this soft rock or made of tuff blocks. This material has been used since ancient times, for its characteristics of breathability, insulation and porosity, combined with wise technique of building according to functional types and elements improved over time, allowed to make inhabitable caves and cisterns and wisely exploit the most valuable natural resource, water. The typical evolution of housing models of the Sassi is the different way of exploiting the natural features and the materials, unchanging over time. The tuff has always been the basic element of this type of architecture, which from the cave becomes constructed, structural layouts reinterpreted by the forms and the natural examples, since the Palaeolithic period. The research wants to investigate the structural examples of the past to confirm the importance of form, technique and the different types of construction on bioclimatic definition of the building , a "natural governor" of the thermal and hygrometrical comfort for an high quality performances.*

1. INTRODUCTION

"Sassi" of Matera are known all over the world, not only for their spectacular beauty, but for the historical, cultural, anthropological, architectural, artistic and landscape value. The history of man characterizes the heritage, as the result of a careful, anthropological and typological housing, careful process of evolution. From prehistory to the early villages, evolving through the use of caves and underground architecture, the housing model has always been used wisely the natural resources available, adapting their needs and requirements. Through the technological evolution, men has been able to devise new methods of exploitation of scarce natural resources, adapting the land for this purpose. The research analyzes the typological housing evolution through form and matter, while the first is divided into two categories, carved architecture and built architecture, the second is characterized by the presence of one formidable material, limestone or "tufo". The complex history of the Sassi of Matera, from popular, peasant and artisan sources, consists of several steps, respecting the original residential vocation. The year 1952 marks a turning point for the history of the place, the Law no. 619, of 17 May 1952 [1], for the "restoration of the Sassi area in the town of Matera", envisages the evacuation of unfit houses and the building of new popular neighborhoods. Trying to impose a new, modern housing model, the Sassi were abandoned in a deterioration state, almost irreversible. Only in 1993, with the inscription of the Sassi of Matera, in the UNESCO World Heritage List, begins the slow process to recover the places, which by popular and farmer district becomes a bourgeois expression with a tourist destination. The theme of Sassi restoration, from an architectural and functional point of view, has lasted over 60 years, establishing such benchmarks, the "recovery Manual of Sassi" Prof. Amerigo Restucci [2] and the "Code of practice" Prof. Antonino Giuffre [3]. From typological analysis is possible to understand the specificity of the technological and constructive solutions, which adapt the architecture to the place, taking advantage of the inherent characteristics of construction material and the natural elements like water and sunshine.

2. TYPOLOGICAL HOUSING ANALYSIS

The Sassi are located on one of the two shores of the Murgia promontory, which, over time, has been excavated and perforated to create caves and cisterns. From here they extracted the limestone, or "tufo" used to build the houses and the entire urban fabric, adapted to the morphology of the territory and verticality. The main type of housing in Sassi was the neighborhood unit, a court in the middle of adjacent buildings, with a large rainwater collection tank in the centre, used as a water resource for the whole neighborhood. Retracing briefly the main steps of the historical evolution of the settlements in the territory, it's necessary to refer to the Paleolithic as the starting point of housing types analysis, because the artificial and natural caves provided a

useful shelter from bad weather during a climatic phase very rigid. It can be said that the housing model evolution is a direct consequence of the needs and the changing needs of the population. During the Neolithic period was established a new settlement model for stable villages, where they could develop new agricultural techniques, such as the product's storage in underground pits excavated or construction of bell-water tanks, as a horizontal progressive enlargement of a vertical hole underground. Other examples of excavated architectures are the rainwater collection tanks or condensation chambers. The shape of Sassi architectures, excavated or constructed, recalled natural forms, on a proper typological and functional interpretation. Excavated architectures are the starting point for the constructive evolution that still now characterizes the heritage, as a work of engineering and plumbing undisputed value. The Sassi are articulated in the Sasso Caveoso and Sasso Barisano, the first with a vertical and terracing stratigraphy, characterized by the type of housing called lamione; the second is characterized by the architecture constructed in continuity to those excavated, forming the courts or neighborhood units.

Figure 1. Part of Sassi di Matera, Sasso Caveoso.

The underground articulation in tanks and connecting tunnels was used to channel and connect a complex rainwater system and the more superficial aquifers collection that intersected the excavated structures. In the typological housing evolution, over the type of pit court, the houses fit to the natural morphological characteristics of the cliffs at the edge of the Gravina, which already were offering natural caves and vertical cuts, from where to articulate the excavated system of underground rooms. This housing model is identifiable because structured on terraces that looked out directly in Gravina and underground structures on several levels. The underground spaces were then used as places of everyday life and as a primary source to extract calcarenitic material, used at first to consolidate the terraces and raise stone walls and later used to build the houses of the Sassi. The housing typological model, founding the architecture of the Sassi, is made by aggregation of adjacent units, surrounding a central space in the court. In this architectural heritage everything is perfect and organic, the architectural language looks onto the natural rock with extreme sensitivity and language is the constructive symbol and the original model of what is on the surface. The cave model evolves through a simple curtain wall of the main opening (buffered cave). Later, with the evolution of construction techniques, barrel vaults are introduced, originally used to encase internally the caves, making healthier wet areas of the caves. The next step is an extension built to the outside of the cave, called "lamione" or "Lamia", a living area in direct connection with the cave, in which was contained the cistern for water supply. The type of “lamione” was a living cell, which was modeled on shape and model of the cave, originally built by the use of calcarenitic blocks extracted from the excavation of the cave itself and so barrel-vaulted. The housing type assumes precise forms, determined by the static of structures, and tends to develop more in length than in width, assuming a longitudinal shape. The width is strictly defined by the need of the walls to support pushing of the vault. Because more the arch is great more the walls will have to be massive, they require precise proportions and building modules. The underground rooms, whose shape and spatial development can seem unpredictable, develop deeper into the central environments, that come down to a height of three meters, following a guided tour of the solar rays that enter within these environments. For this reason the central areas, where the light comes from the front, are deeper, sloping downward and creating different levels connected by underground tunnels and galleries. Recalling how these environments, entirely underground, had just one point of light and ventilation is easy to understand what was the need, in these, to enlighten, heat and facilitate ventilation, during the winter in depth while in summer only in their first part thanks to 'angle of the solar rays. The building typology of the Sassi is vertically, in modular overlap to what can be defined as the basic unit, called “lamione”, tracking road routes on different levels on the upper or the lower level, usually attached to a side stairway or perpendicular to the main facade of the building. From the functional aggregation of multiple building modules, vertically and horizontally, the types and more complex construction building models, mansion structures or court that contain the system of paths, tunnels, tanks and underground sites find their definition.

Table 1: Diagram of housing types. Pietro Laureano, 1997, pg. 128. [4]

Matrix Space	**Promontory**	**Edge and straight steps**	**Degranding terraces around riverbeds drained from tributary of the Gravina**
Basic type	Wooded environment; glade in forest; lucus; Neolithic huts and moats; fences and embankments; bell cistern.	natural caves on the limestone edge; restraint slope of waters and cisterns above the cave, gutters and tank wall at the door; systems of dikes and ditches on the edge and drains.	Terraces surrounded by caves, digging caves as shelter animals, warehouses, barns, humus formation; crops in gardens on artificial terraces with dry stone walls.
Evolution of basic type	Gradual disappearance of forests. Dolines-puli. Short pit excavated in limestone plateau (the Metal Age provides new tools), watersheds for cultivation, excavation of the pit short walls to create shelters for animals, cold rooms for household, barns, cisterns and neviere.	Plugging of the cave, the cave excavation and external projection of its architecture with the excavated material. Lamione. recovery of water from the roofs into the well of the common courtyard.	Prolongation in depth of the caves and use of the final part as a cistern; outward projection of the excavation and use of it as a cistern to build.Neighborhood. Hanging gardens; Use the blade edges for cultivation.
Urban Fabric	Rural farms and built farms. Neighborhoods around a well. Farmhouses and castles.	Vertical integration of the built levels; housing densification; use of tanks network and the construction of large tanks in high places.	
Saturation of the urban fabric	Expansion of the city beyond the limestone edge on the plane and on the hills. Racolta collapse of the network of water. Saturation of the living fabric of the Sassi. Congestion in the neighborhood. Transformation of tanks in homes. Promiscuity housing. Transformation of drainage grabiglioni in roads and separation of Sassi from Gravina and the plateau in front of. The Sassi <<national disgrace>>.		
Sassi Historical city centre	Emptying of the Sassi and the creation of <<modern city>>. Unique urban formation: a big uninhabited historic city center. The culture of conservation and special recovery laws. The Sassi, "UNESCO World Heritage".		

3. FEATURES OF THE MATERIAL

The Sassi are a city built in “tufo”, the houses are made of stone and in the stones. The “tufo” is limestone, and its physical characteristics can be distinguished in litocalcarenites, biocalcarenites and oolitic limestones depending on whether they consist mainly of limestone granules from microfossils or fragments of fossils. From these characteristics and by the stratification of the material, it can change the compactness, hardness and purity. In addition to its mechanical characteristics “tufo” is an excellent material for everyday living, thanks to its thermal characteristics, due to the particularly porous constitutive structure, thanks to its high breathability and ventilation capacity of its original environment. Its thermal conductivity, at temperature of 10 ° C, is about 0.25 W/(mK), defining a mean - low capacity to conduct heat. The tuff

is an excellent insulating material, from the heat during the summer and from warm in winter. The main features of the tuff are:

- Heat accumulation coefficient 1700-2200 KJ/m3K,
- Thermal conductivity 0.85-1.7 W/mK,
- Thermal inertia about 10 hoursore for a thickness di 10 cm,
- Trasmittance 0.6 W/mK (curtain walls) e 1.7 W/mK (structural walls),
- Value of water absorption 1-10 %.

The "tufo" also has excellent ability of thermal inertia in the transfer of heat from the outside towards the inside, while the air exchange from the inside to the outside was secured by constructive expedients, such as small windows or openings located above the main entrance. In this way it was possible to ventilate humid excavated environments in Sassi of Matera. These openings, placed in front, ensured a different illumination of the seasons environments. During the winter, the sun is lower, the rays penetrated to the deepest environments while in summer, the sun is highest, the rays would stop at the surface, illuminating only the initial part of the environment and leaving in the twilight deeper environments. This material also has other important features, such as sound insulation capacity and fire resistance. The specific physical and chemical characteristics of the "tufo" were amplified of the building which required technical big wall thickness, for structural reasons. In underground environments, excavated in the limestone bedrock, these features are even more evident, and the main feature to keep the internal temperature constant creates other problems such as condensation and humidity. The problem of humidity in houses, caused by the thermal differential between the inside and the outside or from infiltrations of water, was solved, in the past, through the natural ventilation of the environments whereas in the present system solutions, although very often invasive and incongruous, provide the necessary artificial ventilation.

3. CONCLUSIONS

The Sassi of Matera are one of the oldest architectural bioclimatic models, thanks to its architectural features, materials, natural and typological, capable of exploiting natural resources. Nowadays the Sassi architecture, underground, or constructed, are the symbol of a great cultural, architectural and anthropological value. The Sassi are a monument to the past when paying more and more attention in order to preserve the delicate inherent characteristics of form and matter. The discounting of the value in use must go through a targeted, precise and accurate recovery process that it can re-educate the everyday life of these same sites [6]. The compromise between the modern requirements and the architectural and landscape value of the place is obvious, but it becomes even more serious if the use value of the assets is related to tourism marketing. The current comfort parameters are quite different from the old concept of habitability for this reason the use of the assets must not be intense and massive but conscious and sensitive, even alternating the use of the sites depending on the seasons and the weather conditions as well as preferring always breathable materials and natural ventilation solutions.

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