EARTHEN BEEHIVE DOMES OF NORTHEN SYRIA

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Abstract
The Vernacular Architectural Heritage is important for our own future because such architectures are characterized by a high level of technical variability and integration in geographical and cultural environments together with their traditionally ecological and effective energy performances, which is of the utmost relevance, consistent "tacit" and local knowledge.
The beehive dome vernacular architectures constitute a cultural and architectural heritage, as well as a technique, shared between the Orient and the Occident. The “tholos” or “beehive” domes result from an ancient tradition of construction, which produced traditional architectures and rural and urban dwellings characterized by environmental performances in hot and dry climate regions. The Syrian architectural culture of the earthen beehive domes “qubab” is rich and varied: in Syria the houses with domes, built in adobe bricks, can be found as little groups of houses or bigger villages composed of hundreds of domes near Aleppo / Sfirs, Homs / Hama, and along the Euphrates River.

There are only very few studies interested in constructions with domes in Syria, although they represent one of the most interesting particularities from the Syrian traditional architecture, and constitute an important chapter of a shared heritage in the Mediterranean area.

This paper presents part of the results of the ‘Coupoles Et Habitats, Une tradition constructive entre Orient et Occident’ project, funded by EACEA of European Commission.

This project, focused on a strong interdisciplinary approach, is implemented in cooperation between the Syrian authorities in charge of Culture and Heritage and a group of European specialized institutions (I, F, B, E, GR) with complementary profiles and competencies.

The main objective is to document the unique historical landscape of earthen dome villages in northern Syria that has continued to express the complex relationship between the environment, people and architecture over thousands of years. A second objective is to examine the common roots between East and West demonstrated by the astonishing diffusion of corbelled architectural and building culture all over Europe and the Mediterranean.

1. PROJECT: BACKGROUND, OBJECTIVES AND ACTIVITIES

The dome building is a cultural heritage architectural and construction technique shared between East and West.

The interest to deepen the knowledge of this architecture and to draw attention to a world heritage in danger, has given rise to a 24-month project focused on earth architecture domes in Northern Syria. The project "Domes and Habitats, a building tradition between East and West", is part of the "Culture 2000" European program and is developped by the University of Florence (coordinator), Hellenic Society (GR), École d'Avignon (F), CNR-ICVBC (I), Universidad de Valencia (E), University of Liege (B) and Directorate General of Antiquities and Museums of Syria.

The project studies at same time the origins of corbelled dome architecture and ‘tholos’ in Mediterranean Region (Syria, Greece, Etruria, Near East, Italy and Portugal) and the today Syrian earthen corbelled dome architecture in its rich variety of history,

architecture, construction methods, art and traditions, binding Syrian earthen architecture to deep roots.

The programme of activities aims at:
- studying with an exhaustive and inter-disciplinary approach, the construction “language”;
- developing training and information activities towards the persons in charge of this heritage;
- developing activities of dissemination of knowledge linked to this shared heritage, by an exhibition (models, pictures, models CAD 3D, educational notices), and a catalogue of the exhibition;
- defining recommendations for conserving this heritage.

A field mission took place in spring 2008 in selected villages of the west region of Lake Jabboul and Lake Assad, and in the east region of Hama (Fig.1), during wich the following scientific tools were applyed:
- analysis and characterization of materials, building techniques and construction process;
- survey and modeling 2D and 3D architectures dome;
- mechanical analysis of domes by direct analysis of the forms, building elements and materials;
- archeotechnical analysis building process;
- archeometric analysis of building materials.

The main scientific goal is the identification of a building culture and conservation strategies according to user needs, technical risks reduction and improvement of building process efficiency.

Fig.1 - Selected villages for field surveying. (credits: Picture from Google Earth redrawn by Dipasquale L. 2009)

2. DOMED VILLAGES CONTEXT

The earthen architecture is deeply rooted in the Syrian tradition: the excavations of ancient times have shown that in Mureybet, a Neolithic site in the middle valley of the Euphrates, the population has used the earth associated with pebbles and elements of wood and straw to build the oldest type of circular houses of the region and probably in the world. Many factors affect the characters and distribution of corbelled earthen domes: geographical, climatic, water and building earth localization, traditional, social and economic. The territory of the northern Syrian plains was for centuries a favorite place for tribes of nomadic or semi-sedentary herders of sheep and goats rarely. It is a region of hills and plains, bordered by rivers during the rainy season and early spring, adapted to grazing, where the Bedouin tribes were organized into small villages, preserving their traditional way of life based on economy of sufficiency. The villages are located near water points at the foot of hills, often on the ruins of former Byzantine colonies settlements.

3.THE URBAN MORPHOLOGY OF VILLAGES

The principles of transition and self-construction that characterize these ways of living are the basis for understanding the process of formation and evolution of these settlements.

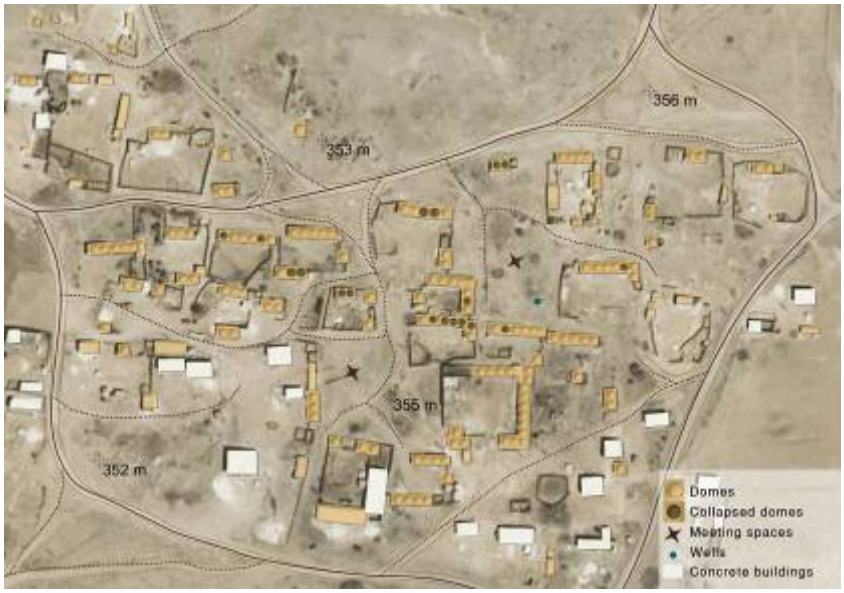

Fig.2 – Plan of the village of Arbaia. (credits: Picture from Google Earth redrawn by Devaux E., Dipasquale L. 2009)

The urban organization of these villages, whose habitat is still organized in groups more or less dense, are built in two main types of arrangement: "free" or "structured". The "free" organization (Fig. 2) presents housing units dispersed over the territory and an irregular and spontaneous path system. The "structured" arrangement presents an organization of the location of housing units, often in blocks, and a structured disposition of the circulation and meeting spaces.

4. THE ARCHITECTURAL MORPHOLOGY OF CORBELLED DOME HOUSES

The earthen dome house originated and evolved over time, stemming from a willingness to apply and develop the most appropriate solutions to meet human needs in relation to the potential and resources of the environmental context. The geometry of the dome itself is not a product of clear intent, but is rather a product in its form and design of the collective intelligence of communities inhabiting the regions of the Middle East (Fig 3).

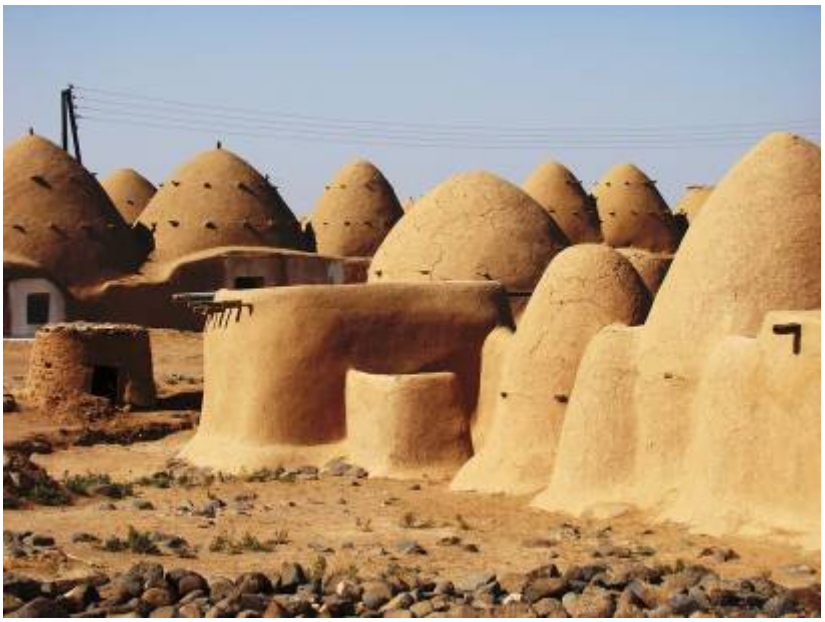

Fig.3 – Photography of the village of Arbaia (credits: Nazir Awad, 2008)

4.1 The living unit (*dar*)

The construction model is based on the combination of several cells or blocks, which are arranged around a central courtyard. Built spaces are reduced to a minimum: the daily life of the family, the daily preparation of bread, meals, family reunions and children's education and play, is spread out.

The basic forms of aggregated units, though not easy to categorize, can be distinguished as either 'closed' and 'open'. In the former, a central space is enclosed by buildings and a fence wall with a small entrance passage. This fence wall is generally low, thus allowing a view of the courtyard while still preventing access by animals or outsiders, though only in rare cases is it secured by locking. In the latter case, the organization is rather different: the main unit can be surrounded by other complementary buildings but the limits of the units are not defined. Communal and private spaces in this case are somewhat mixed up where areas belonging to a particular house may also be used as common thoroughfares.

Individual domes group together to form dwellings which, in their various forms, depend on certain factors related to the social characteristics of the owner/builder of the house: the state of well-being of the family, the frequency with which the building is used, type of farming adopted (crop-agriculture or pasture), and the number of components in the nucleus (Fig. 4).

In the courtyard (*Haush Sahn*) are spread the various functional cells for housing, surrounded by a fence wall in the ground (*sur*) or by the construction of the house. It is a space highly dwelt: here can be found small fences or shelters for animals, small domes used as chicken coops (qunn) and in some cases, a fireplace, for the preparation of meals at the center of the courtyard, or in an adjacent area to the house, you can find a well, (be'er) able to meet the water needs of the family.

The unit is ordered from the main unit housing function, which can be formed from a single building, with an internal length of about four meters each side, or two blocks, connected to each other, through an arch, called *qantara* or *nhit*. The main cell, used for livign, is frequently oriented on the line north-south, with the main opening to the south, to benefit of solar irradiation, which penetrates from the large opening, and the intention to protect the house from winds from the east and north-east. This space has

a multifunctional character: during the day it offers an area of residence and shelter from the harsh climate and during the night it hosts mattresses for sleeping. Around this space other cells are added over time, each of them with its own specific role. There exists an implicit hierarchy in the relative position of the dwelling area in respect to the storage area.

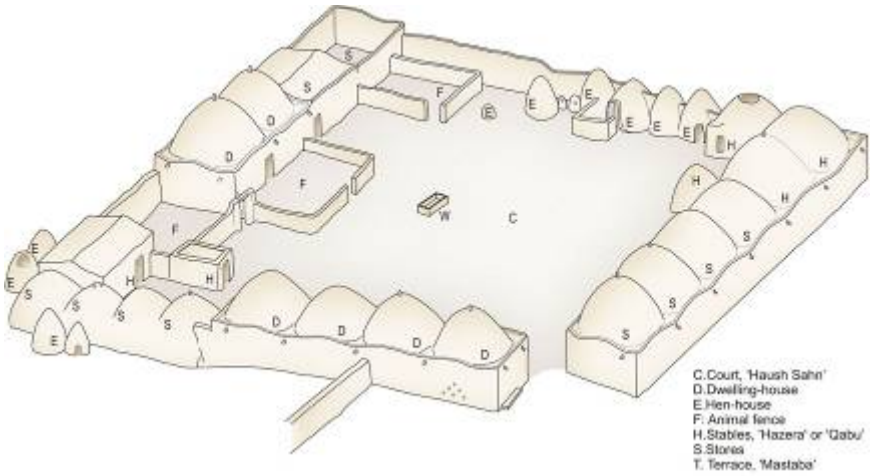

Fig.4 – Drawing of a living unity in Oum Aamoud Seghir (credits Onnis S, Dipasquale L., 2009)

Besides, the dwelling area usually has a raised terrace (*mastaba*) from the ground at the main entrance of the house.

The interior is free of fixed furniture. Blankets, and in some cases, thin mattresses are placed in a corner of the room (frash), one over, and only at night, are arranged on the floor, to sleep. The objects are placed in niches (*khezana gedaria*), produced in the thickness of the masonry. The main walls for housing can be decorated with reliefs (*raff*), always made in earth, which include floral or geometric pattern, or form small shelves. The holes are small and rare. They consist of small slits in square, rectangular and round (*taqa*) and are usually oriented towards the east or the west, to capture the summer breezes, and to allow night ventilation and daylight weak. In the most recent housing is often found windows (*nafeza* or *shubbak),* which are almost always on the main prospectus.

4.3 A classification of corbelled dome houses

The repertoire of dome-shaped structures, while referring to a constructive one, which is the cover dome bricks arranged overhang, is available in a wide variety of types. The typological solution adopted is strongly linked to resources and availability of materials from the place where the building is born, and how the original model has undergone changes in order to better adapt the space to the needs of housing.

From the variety of domes observed, we can identify types of constructive applications which are meaningful, differing from the other formal and constructive character. Nevertheless the imposing character of the dome in its building's shape, independently from the architectural variants to be shown in this text, the lay-out of these cell unities is always square. Occasionally, there exists however some circular modules of reduced dimensions which are used for storing, and also covered by smaller domes.

The different height of the perimeter wall and the domes profiles may help to distinguish clearly different types of domes in the vernacular landscape of the northen villages in Syria (Fig. 5):

- *Simple dome,* in which the dome rests on a stone baseboard that rises a few cm respect to the campaign floor. The building has ogival profile; the shell of the dome

is entirely visible from the archway soffit or the extrados. The size of the Sultan domes plants observed vary in a range of 3,0-3,5 m 3,0-3,5 m. The height is variable from 4.0 m to 6.0 m.

- *Sultanya Dome* The building consists of a wall box, with dome cover profile ogival-paraboloid. From the outside the two elements, the box walls and dome, are clearly identifiable, however from inside the transition from one rectangular box and cover move occurring seamlessly. The box has a square base of a plant the size of which is varying from 3.00 m but 4.50 m. The development ranges in height from 4 m to 6 m.
- *Domes set on low stone basement*: The building comprises a stone basement, of variable height, and a shaped profile at the aperture, on which rests the adobe dome.
- At the formal level, this type is due to the real dome, while the characters and structural design are those of the Sultan dome. The roof dome is not enclosed by a wall, but its shell is visible from the archway soffit or the extrados. Sizes in plant development and height are contained in 2.5-4 m
- *Plan roof Domes*: the dome is not completed, but the top is closed by a cover with a wooden structure covered with earth. This type of construction is now widespread in the villages near the Euphrates River, where the availability of wood branches helps cutting the dome's construction by a flat roof.
- *Smaller domes in cob:* this type of dome is used only for the service areas (stock, silos, animal shelters), and the structure is made of earth shaped by hand and stone.

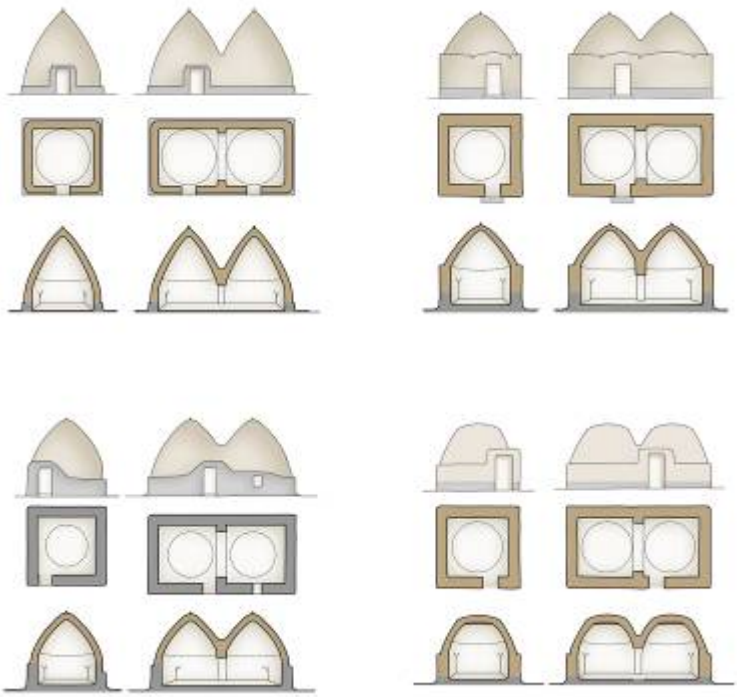

Fig.5 – Main types of domes in the Syrian vernacular landscape. From top left: Simple dome, Sultanya Dome, Dome set on low stone basement, Plan roof Dome (credits Dipasquale L., 2009)

5. BUILDING CULTURE OF CORBELLED DOME ARCHITECTURE

5.1. Materials

In the conditions of scarce resources of the steppes and the uplands of Northern and Central Syria, the availability of a material such as earth, thanks to its ability to integrate other materials and its cultural plasticity, results in a high level of cultural diversity as regard to building techniques.

The manufacture of bricks is still today a family production under the supervision of an experienced builder, the *muallem*. Preparation of the earth mix is done by the men, while women shape the bricks with the help of a wooden form: the involvement of the whole family in the construction process (collectively *gath elleben*), which also involves children with different tasks depending on their ages, is significantly reducing the cost of the bricks.

The earthen masonry technique (*adobe*) is integrated, for buildings of modest structural and functional importance, with the technique of *cob*, which is an *in situ,* hand-modeled earthen wall.

New industrial materials have been introduced in the last decades for their ease of use and connotation of modernity: still using a smaller part of the traditional architectural knowledge (design and construction). These materials do meet certain requirements such as reduction of maintenance needs and identification with the urban and modern way of life, but they fail, however, in other more important requirements such as hygrothermal comfort, energy efficiency and general sustainability: environmental, economic and cultural.

5.2 The building process

Once the location and orientation are determined, the perimeter of the building is traced. The mason digs until he finds a solid layer of soil (average depth 40-60 cm) and builds the foundation with stones and earthen mortar. Above the foundation wall a stone wall of variable height is built, upon which the earthen masonry wall will be erected.

The elevation wall is interrupted for openings, niches and for the arch linking two cells. The wall is built in horizontal layers, with particular attention given to the connection between the walls; at a variable height before starting the pendentive the arch is built, which will support the bricks of the former (Fig. 6).

The base of the dome is a stone and mud wall, dug into the ground until the depth of a solid layer: the buried part of the wall is the foundation, normally with the same thickness (65-80 cm) of the supported wall, while the part above ground level is a socket to protect the building from erosion by rain water and soil dampness.

The stone walls are usually protected by an earthen plaster, often finished with a coat of limewash The stone walls are always composed of two external vertical layers, not connected by orthogonal stone elements; the space between is filled by a mixture of earthen mortar and small or medium sized stones, in a double wall technique. The mortar is made with earth (clay and sand), and sometimes added with straw.

The earthen brick (*adobe*) wall is an elevation wall built on the base, a characteristic of the sultan dome houses. The wall is usually three-headers, sometimes four, thick. The two heads wall thickness is found only in the case of small and light domes or for flat-roofed buildings. This kind of wall is part of the building system of sultan dome houses.

The size of the brick varies from village to village, having regular proportions between the three dimensions of the brick, and in particular the approximate ratio of 1:2 between width and length of the brick: the average size is 20 cm x 40 cm x 10 cm. The horizontal and vertical joints, which have variable thickness, when skilfully done, are made with sieved earth mortar, often mixed with straw. The realization of a ‘three headers’ wall is regularly accomplished by alternating the brick layers and avoiding the alignment of vertical joints.

The set of building parts realized to achieve the transition from the square base wall or elevation wall to the circular base of the dome, more or less regular, in is called ‘pendentive’: the rows of bricks gradually take the shape of the internal perimeter from a square to a circle.

The use as a shelf of a piece of wood or a stone in the corner allows a greater overhang, facilitating the creation (i.e. less then 12/15 rows) of a circular base for the first brick layer of the dome. The height of the starting point of the pendentive varies from 20 cm above the floor (normal dome), up to 1.5 meters (more common) or more (sultan dome).

5.3 The corbelled dome

The corbelled dome is realized by laying the earthen bricks according to a continuous helicoidal spiral, tapered and often tilted towards the centre.

The laying of the bricks according to a spiral permits laying in continuity without interruption and completing the horizontal rings with brick fragments. The mason lays the bricks, perched on the ring of the dome, in an anti-clockwise direction to favour the use of his right hand. This allows the construction process to proceed more efficiently, without any scaffolding or need to adjust the bricks.

The mortar is made with earth (clay and sand) and sometimes straw, as for the mortar of walls. The thickness of the mortar is considerable (2 cm) compared to the thickness of the brick (4-6 cm).

The overhang of bricks in relation to the lower layer is obtained by hand and without instruments. In most cases the bricks are tilted a few degrees toward the centre of the dome. On the top of the dome the laying beds are more sloped inwards due to the weight of the jutting bricks and the amount of mortar used for laying.

The mason, balancing himself on the ring of bricks backs up as he lays the bricks. When the top of the dome is approached the working position becomes increasingly awkward and dangerous, the rhythm is slower even for the harder work of lifting bricks up to the working layer, until the point where the mason is forced to work from the outside, finding foothold on the protruding stones with arms outstretched to lay the bricks. The protruding stones, flat and long (sometimes replaced by wooden elements), are fixed in the dome wall to protrude in an appropriate measure to support the foot of the constructor.

The top of the dome is executed with great accuracy, both formal and functional, as this part is the most prone to degradation and the most architecturally expressive. The tantour is a sort a pinnacle fixed on top of the dome as a completion. It consists of two parts: the pinnacle itself and the bricks where the tantour is fixed. At the top of the dome when the arrangement of the bricks into a spiral becomes difficult, the mason lays bricks horizontally to close the void, adds layers of clay mortar and fixes in a standing stone, the tantour, at the top.

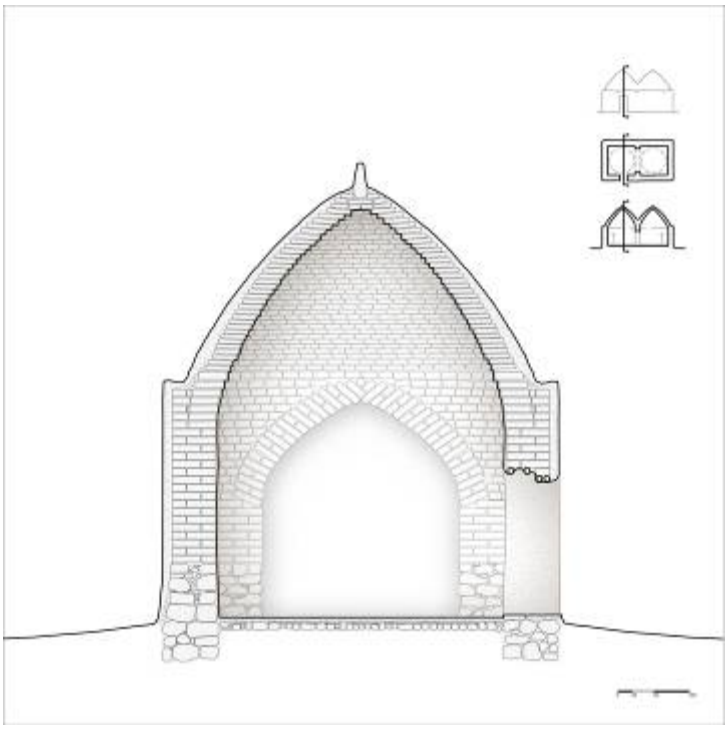

Fig.6 – Vertical construcitive section of a Sultanya Dome (credits Onnis S., 2009)

6. CONSERVATION OF CORBELLED DOME ARCHITECTURES

The conservation of corbelled dome buildings has always been part of a natural process developed over the decades by the population of northeast Syria, who has passed from generation to generation the tacit knowledge associated with the practice of construction of buildings and regular maintenance, in order to prolong their useful life. Practices such as the remaking of the plaster coating every year after the rainy season, or making sure that capillary moisture or any kind of infiltration does not affect the walls built of earthen bricks, have been for many decades part of the natural process of maintenance.

If this process is interrupted for any reason (because of cultural and/or technical factors), then the building falls into a progressive state of degradation, which could be stopped only if maintenance is carried out in time, because the earthen material is particularly vulnerable to the degradation produced by certain environmental agents. The collapse of a portion of walls, for example, can cause the collapse of the whole building, and the rain water that infiltrates from this failure can reduce the resistance of the material. Nowadays, corbelled dome houses, are in different states of conservation depending on the village: in those where people live and still have a strong care for the maintenance of the houses, they are in good condition; in those where the population has begun a process of migration, and when there is no longer an emotional link with the buildings, they begin to deteriorate gradually; abandonment is, therefore, the primary agent of degradation.

6.1 The cultural factors of degradation

The advent of modernity has led, on the one hand, to the migration of populations towards the city, and hence the abandonment of the domes, and on the other hand, to the emergence of new constructions with types and techniques that do not comply with the originals, which are gradually changing the character of the villages. Most types of deterioration in the corbelled dome buildings are the result of this gradual process of abandonment and lack of care. This phenomenon is increasing because of a disinclination of the inhabitants to value the heritage that this singular architecture

represents.The new mentality rejects traditional constructions as being associated with the poverty and self-sufficiency of the past. So, the first step to stop the abandonment and the deterioration process must be made from a reflection on the possible adaptation of these spaces to the contemporary needs of the inhabitants.

6.2 The technical factors of degradation

The corbelled dome structure, from a geometric point of view, is stable, and if it is well made, it seems to be an excellent solution both from constructive and functional aspects; its weakness is the material vulnerability (the earth) to environmental actions, which increases if the dome is subject to a lack of regular and careful maintenance.
The static principles that the earthen bricks system is based on are the same as for the simple masonry construction: the structural elements (walls) work in compression. However, earthen constructions have lower mechanical performances (in terms of strength and stiffness), which can promote the development of certain types of pathologies. Earthen constructions also differ from brick masonry substantially for an especial sensitivity to the effects of water: the water runs down the wall or goes up through capillary moisture, which, if not checked, can produce numerous pathological effects. Since the earth is essentially an inconsistent material, it can take on several states depending on the water content. Particular attention should be directed to the solutions that ensure the protection of buildings from rain, capillary humidity and any type of infiltration.

6.3 Strategies and actions for the conservation of corbelled dome villages as urban and architectural landscape

As in any other part of the world where vernacular architecture still survives changes in the traditional economy, in this case of the beehive domes, the choice arises between either:

- conserving and restoring vernacular architecture independently of the disappearance of the social and economic context that once generated it;
- or allowing change to take its course and consequently the gradual extinction of such architecture.

Maintenance, conservation and restoration works in vernacular architecture represent a preponderant economic investment in manpower, one that remains in the area of the restored building, while any new-built building represents a preponderant investment in newly-bought materials or machinery, both of which come from other cities or even other countries. That is to say that any investment in restoration is to the advantage of the development of the local economy through the work given to its craftsmen, artisans, carpenters, smiths and local small industries.

Restoring these dwellings is indeed possible, however, even employing traditional materials and techniques for repairs, attitudes would differ from a local inhabitant who would otherwise discard any reparation and rebuild the whole building. Restoration may and sometimes must resort to the reproduction or interpretation of local constructive techniques or even to the innovation of solutions in order to achieve maximum suitability and compatibility with the existing building (Mileto and Vegas, 2009).

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Notes
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Curriculum
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