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To cite this article: C Azil *et al* 2018 *IOP Conf. Ser.: Mater. Sci. Eng.* **353** 012009

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Desert rose: building material of cupolas in the Souf in Algeria

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Abstract. In the Souf of Algeria, the roofs of all constructions are arranged like corbelled domes, built with local particular material to this region, which is the desert rose. These cupolas describe a unique landscape of historic centres. Such constructions include a widespread and precious heritage that deserves protection to save this urban landscape which constitutes an element of identity of heritage built upon the material as well as the immaterial of the local know-how. Unfortunately, these architectural elements have undergone alterations that devalue the urban landscape and destabilize the buildings. However, the structural system that provides stability and endurance to this day remains an open question.

In this paper, we describe the role of desert rose cupolas in the construction of a single urban landscape and we contribute to this knowledge. Then, we explain the role of the availability of the materials locals (desert rose and tafza) to appearance and emergence of construction with cupolas typology. In addition, we describe these materials locals, and the method to their usage. In the end, we have traced the process of construction of these cupolas by corbelling which is mounted by successive courses of the desert rose and the plaster mortar.

Keywords. Dome, Desert rose, Tafza, structural analysis, local material, building heritage.

1. Introduction

In the Mediterranean basin, several cities are known by the use of cupolas in all constructions. The latter constitute true heritage values to be protected, and to transmit this know-how to future generations.

In the Souf region of Algeria, all buildings have cupolas. This use has appeared since the founding of three historical cores in this region namely *Guemar*, *Z'goum* and *el Oued* towards the end of the XVI century [1]. The cupolas of this era are built with desert rose material.

These local materials played a large role in the construction of a particular vernacular architecture specific to this region, especially through the use of domes.

Consequently, these major architectural elements describe the urban landscape of this region, which is an identity element of the culture in the Souf region. The damage suffered in all these cupolas devalues this urban landscape.

Therefore, it is important to recognize this material its sources, and the way of its use for the construction of domes and in some cases the walls of these vernacular dwellings.



2. Materials locals: a factors of emergence of architectural typology “cupolas”

The old-style landscape of the Souf is denoted by a particular beauty due to the originality of the site "a human establishment produced in an erg". The splendor does not count only in the movement of the ocher or white dunes of the erg, but also in unexpected human creation [1].

The specificities of a built environment are severely related to the characteristics of the human and natural environment to which they relate, and some of their architectural and constructive features can be found in the conscious choices made by builders in relation to the context of and the presence of exceptional natural phenomena. Therefore, we expose the natural factor that contributed increase to this typology particular to the Souf region in the use of domes.

2.1. Factors of emergences: Form, technique and environment

The architecture of the desert in Algeria is vernacular. The construction of the Souf was carried out without the technical support of an architect or an engineer.

Vernacular architecture was considered by Giancarlo Cataldi as typically the fruit of the indissoluble union between a given natural environment (context) and a determined human culture [2]. We interest at the first factor which is natural factor.

By crossing the correlation between technique and form, he considers building materials as a major factor influencing the development of an architectural and structural typology [2]. As a result, in the Souf region, the lack of wood, which allows large crossings, has eliminated the use of flat roofs in this region. On the other hand, the presence of a material, which has a certain adhesion and a resistance to compression important by its architectural morphology, which is "the desert rose", which determined the constructive typology of the relative cupolas [3].



Figure 1&2. Old quarter in Guemar, Souf [4]

Over time, the crossing of these multiple factors, namely: the function of a structure, the static system, building materials and the historical era, gives rise to the consolidation of architectural forms and technical solutions characterizing precisely this environment, in symbiosis with this human society that is established there.

3. Building Materials local : Sources and Methods

3.1. Building materials: provenance

The unusual architectural sense of the *Souf* is due principally to the variety of the particular materials existing on the spot. The ground and the subsoil of the Souf have impressive opposites, there are frequent sand in the erg, *tafza*_ limestone _, and the desert rose _ or *Lous*_ [5]. These two building materials are scattered in the soil and the subsoil.

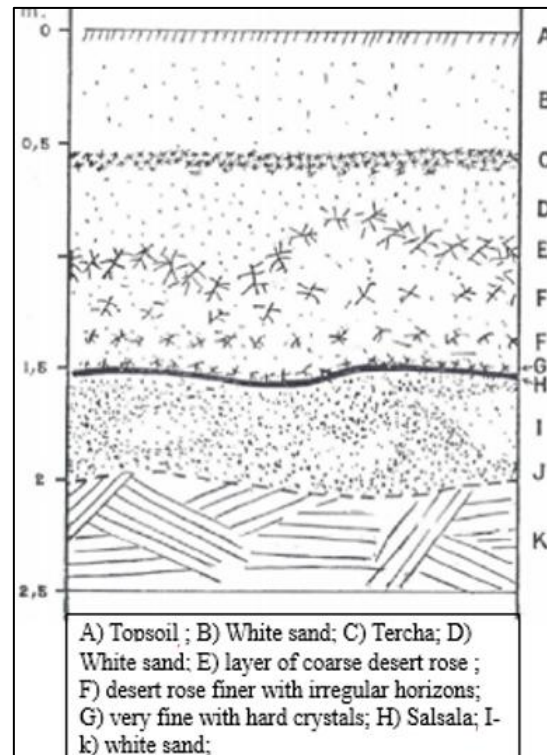


Figure 3. Schematic soil section [6]

In addition, the gypsum solidification of the region produces rocks of various sizes and shapes, namely, the desert rose - *Lous*- . it is made of interleaved spearhead crystals up to 20 to 30 cm in length, solid building stone in the form of coarse rubble very resistant to building [7]; *Tafza*, which is a white sandstone containing very little sand, often quite hard. The latter constitutes the raw material of plaster, it is used as binder and coating [6]. We quote that there are other materials used in other structural elements in the image of the *Salsala* used in for foundations and walls.



Figure 4. The desert rose material [5]



Figure 5. The material of tafza [5]

3.2. Building materials: preparation

Each material has its own way of preparation so that it can be used during construction. The desert rose apparent and flush with the ground is picked up by hand. However, extraction work is necessary

if the stone is deep; several tools are used for this work, such as the dynamite process, due to the hardness of this material often used because of its strength and its impermeability in these construction types (dome) [5].

By passing to the material *tafza* which serves to produce the local plaster. It is necessary to rid all the upper layers that can be constituted of the desert rose or of the sands to arrive at the compact mass of *tafza* in the ground. The deep layers of the latter, which are in contact with the water table, are moist, so it needs to be dried once extracted; on the contrary, the upper layers are dry. The steps of extracting it begin with the disengagement of large blocks of the ground, by performing cuttings to obtain parallelepiped kinds. Once isolated this mass is broken into stones of smaller dimensions in order to go to the oven for cooking. After two hours of cooking *tafza*, it takes at least two days for the finished product to cool down. *Tafza* crumbles inside the oven but this work ends by reducing it to powder [5].



Figure 6. Stone and mortar of a wall of an old rural house in the Souf [5].

3.3. *Methods of building cupolas of desert rose*

By the processes linked to the previous materials, the cupolas were made easier to build. It is the unit of design for the interior space (same unit of size of the rooms and the roof). Juxtaposed cupolas can be multiplied to increase the number of adjoining rooms (twice or more) and enlarge the spans [5].

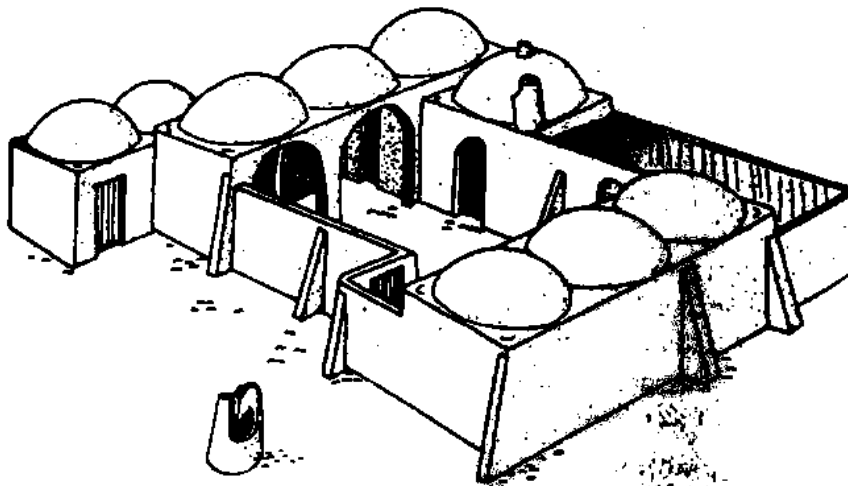


Figure 7. House of the Souf area [1].

It is self-supporting cupolas that are slightly flattened (lowered cupolas), or its height is about half its diameter. It is constructed by corbelling, mounted without formwork by successive courses [7]. It

cannot exceed a diameter of 2.50m. Therefore, the gauge of the parts is closely related to the roof gauge [1]. The shell begins with a thickness of 20 cm and decreases slightly at the top [5].

For its realization, using the material desert rose and plaster, the mason ascends the successive courses, in corbelling one above the other, until it ends in the center. This conduct of the construction is made possible because this plaster has a very fast grip [1]. Its shape of basis is square. The execution of this cupola is made on a base composed by walls or arches flattened at the same level. Then, by building small squinch with plaster and handle by handle. After, sitting up sitting with a material of a rose of sands and plaster. This cupola is much flattened, or this form is close to a cloister vault, but its edges would be curved. By coating these cupolas with an exterior coating. Some cupolas are not coated.



Figure 8. A cupola of a rural house [8].



Figure 9. A cupola of a rural house [5].

The base of the dome is sealed, in these quarters side by side with the walls of the space concerned which in one sense, can have an arcade interruption supporting one side of the dome. The stones at the top of the walls allow the hanging of the copula [5].

In the Mediterranean region, architecture dome, building with local materials, has an important place. Among these architecture, it is important to mention Syrian architecture. The latter is built with the local material “the earth”. The cupolas of the architecture of Syria are built without formwork, with the corbelled method. The shape of these cupolas is conical, it is different in the shape of the desert rose domes. The factors of emergence of the dome architecture in Syria are similar to those of the architecture of the Souf, which are because of the absence of wood [9].



Figure 10. A dome of Syria region [9].

3.4. *Other use of building material local: the desert rose for building walls and foundations*

The Desert rose is also used in the building of the other elements in the *Soufi*'s houses.



Figure 11. An old rural house building by desert rose [5].

3.4.1. Foundations. This stone is used in building of foundation of houses. Since the Soufi house was often a one-storey house, the foundations are almost superficial and of course continuous, with a thicker width (45 to 50 cm) than that of the wall (30 to 35 cm) with a depth of from 50 to 70 cm. This foundation made of desert rose stones and plaster. The desert rose stones used in the foundations are hard and large.



Figure 12. Foundation of old house with desert rose [5].

3.4.2. Walls. The desert rose is also used in the construction of certain walls bearing the rural houses of the Souf. The walls of houses are usually 0.30 m thick, a height of floor between 2 to 2.5 meters.



Figure 13&14. Profiles of walls of old house with desert rose [5].

The stones is bound with a plaster mortar. The shape of the stone is very irregular, so it needed to fill all the interstices with plaster and small stones.



Figure 15. Texture of walls of old house with desert rose [5].

It clear that such material has added important values in the architecture and construction of the desert in Algeria, because thanks to him, builders can build houses with simple principles without the need for formwork, nor the need for polished. Thanks to its resistant the thicknesses of the walls and cupolas are not very big. Its texture in the construction adds an aesthetic value thanks to its form decorated by relief gathers to roses. On the other hand, the Souf's house is also known for its pleasant thermal comfort in the different seasons thanks to the use of copulas. This copula is a conceptual solution, which considered as an isothermal device because this form will heat up less quickly because the volume of the room with copula is large.

4. Conclusion

Through this first contribution to the knowledge of material local of the region of the Souf, namely: the desert rose and *Tafza* stone. The historical analysis gave us that availability of this locals materials

constitute factor of appearance of typology architectural, which is building cupolas. In addition, we have described these materials, their provenance, their preparation and how they are used. In the end, we have traced the process of construction of these cupolas by corbelling which is mounted by successive courses of the desert rose and the plaster mortar. Therefore, we explain the other elements of building, which is constructed by this the desert rose material, as like a foundations and walls. After this study about this material and their role for construction of an important architectural vernacular heritage, it is necessary to study of the contribution of this material to hydrothermal comfort of the constructions.

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