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CONCEPTUAL MODELING OF ENVIRONMENTAL DEVICES OF A VERNACULAR HOUSE WITH A PATIO

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Abstract- The model of the traditional house with a patio has always been considered one of the great models of urban habitat known in history. It has been maintained over time. It has been refined, sophisticated, and even continues to be relevant. This environmental and cultural device continues to live on and to be a source of inspiration to contribute, in a spirit of sustainable development, to our adaptation to the world of today and tomorrow. We will reveal in detail the spatial arrangement of the Constantinian house, as well as architectural devices related to environmental preservation while employing a computer tool to produce conceptual modeling. To study and describe the traditional dwelling, we used the EA entities/associations conceptual model. This type of model seeks to identify a domain's concepts in order to describe it. Thanks to a semantic abstraction, the modeling enables the definition of the house's concepts and places. The physical portion identified visually in the house guides the orientation supplied to this abstraction.

Keywords: Constantinian House, Conceptual Modeling, Environmental Devices, Environmental Efficiency, Entities/Associations, Patio.

1. INTRODUCTION

The model of the traditional house with a patio has always been considered one of the great models of urban habitat known in history. It has been maintained over time. It has been refined, sophisticated, and even continues to be relevant. This environmental and cultural device continues to live on and to be a source of inspiration to contribute, in a spirit of sustainable development [1], to our adaptation to the world of today and tomorrow. Thus, a proper understanding of this model of houses could improve the adaptation of cities to the new climate data imposed and generated by climate change in the urban environment [2]. And even serve as an appropriate reference for bioclimatic adaptation of housing in the era of energy-saving and sustainable development.

For this reason, the design of the traditional habitat has often been described and stated as a true lesson of architecture. It fascinates by its principles and the materials that it uses the connoisseurs in the field of the building as much as the followers of a holy, peaceful, and comfortable way of life, it showed during centuries of remarkable energetic efficiency in particular by its behavior of adaptability with the climate [3]; All its characteristics required a constructive genius that we will try to trace and to highlight in order to take advantage of it for our contemporary conceptions precisely in an urban environment.

Traditional architecture in Algeria is no less specific because it combines culture and climate [4]. Several famous architects, including Le Corbusier, testify to the uniqueness of Mozabite and Algerian houses. Andre Ravereau developed a city's philosophy based on this architecture without architects: "beginning from man's basic necessities, analyzing local resources, the climate, building without embellishments, in the strictest logic" [5].

Indeed, the return to the characteristics of the traditional architectural model adapted to local, social, and climatic criteria in the field of construction, is increasingly recommended by experts in the field [6,7, and 8]. These characteristics allow in addition to energy-saving, the sustainability of the construction as well as the protection of the environment while preserving the Algerian and Maghrebi values and traditions. Through this article, we will see the example of a traditional house in Constantine where we start with the following questions: What are the environmental devices present in the Constantinian house and their contribution to environmental efficiency? How to develop a conceptual model identifying the Constantinian house and summarizing the relationship and interrelation between these environmental devices?

We will expose in detail the spatial organization of the Constantinian house, as well as the architectural and technical devices related to the preservation of the environment, through our case study, the house Dar

Chikh Al-Arab, which is located on the traditional street of Mellah Slimane, Souika in the medina of Constantine. To study and describe the traditional dwelling, we used the EA entities/associations conceptual model. This type of model seeks to identify a domain's concepts in order to describe it. Thanks to a semantic abstraction, the modeling enables the definition of the house's concepts and places. The physical portion identified visually in the house guides the orientation supplied to this abstraction.

2. LITERARY POSITIONING OF IMPORTANCE OF TRADITIONAL HABITAT IN ALGERIA

The traditional habitat composes the greatest part of the man's-built environment; the analysis of the construction and the use of this habitat make appear fully all the rich nesses, are thus revealed the deep knowledge of the environment, the materials, the practical and social needs. The extraordinary amount of technical knowledge (particularly in terms of energy and material saving), and the possibility of adaptation contained in the traditional habitat, are part of the human heritage that it would be essential to take advantage of [9, 10, 11].

Today, if all the definitions and terminologies that have been used for this habitat (vernacular, spontaneous, architecture without an architect, etc.) are unsatisfactory, it is because they all relate, through an ethnocentric vision, to the form, essentially in its aesthetic aspect and corollary in its functional aspect. On the other hand, the habitat translates in surface and volume, the principal aspects of the culture and the way of life. It is the environment, built and not built where the man lives and works.

The architectural devices and the spatial organization of the traditional Algerian houses will thus be evoked without dwelling on the particularities of each region. What is important here is to focus on a specific model: the traditional house with a patio, in a specific context; the Constantinian one.

By focusing on Algeria, the famous geographer Marc Côte underlines the remarkable variety of its habitat, from the high houses of the Kabyle villages, the terraced constructions of the Auresian and Mozabite Dechras or villages [12], the adobe dwellings of the cereal plains, the traditional patio houses in the Casbah of Algiers and the medinas of Tlemcen and Constantine, to the cubic houses of the red earth of Saoura, and the dome-shaped constructions of Oued-Souf. These buildings reflect the variety of materials used, adapted to the environment (earth, stone, wood, gypsum, ...), and the diversity of construction techniques.

At present, the taudification of Algerian historic districts puts the traditional model at risk [13, 14]. The traditional fabric still survives in some central districts of our cities, while it constitutes in our opinion an essential reference of inspiration to create "Savant" architecture merging the architectural creation of the 21st century and the traditional know-how.

The traditional habitat in Algeria is therefore an indispensable source for the study of climate adaptation of the building [15] in comparison with the contemporary habitat which consumes more than 25% of the national energy consumption. The building sector emits a high rate of greenhouse gases responsible for global warming.

On the other hand, the contemporary habitat that lacks conceptual solutions for climate adaptation [16], tends to use active means for heating and cooling, these energy needs increase in a horrible way that may threaten the balance and sustainability of the entire planet. In the region of Constantine or the climate and relief make a particular combination, the practice of traditional habitat to develop a set of clean conceptual solutions which allow him an excellent adaptation to the climate as well as low energy consumption [17]. The goal of this research is to define a field by recognizing its concepts in Constantine's traditional habitat.

3. RESEARCH METHODS

In the first step of our methodology, we planned to expose in detail the spatial organization of the Constantinian house and to identify in detail the architectural devices contributing to the environmental efficiency, while using the computer tool to achieve conceptual modeling.

Each selected device will be defined, while respecting its original name inspired by the local Constantinian dialect, will be illustrated, and located in the plans and sections of the Constantinian house, and then we have highlighted its technical contribution to environmental efficiency.

Conceptual modeling to analyze the environmental efficiency of the traditional house:

To examine and characterize our traditional home, we used the EA (entities/associations) conceptual tool. This methodology seeks to find a domain's concepts in order to describe it. This approach of work is proposed to apply the ideas of conceptual modeling. Thanks to a semantic abstraction, the modeling allows for the definition of concepts. The visual identification of a tangible portion of the house guides the orientation supplied to this abstraction. We went with the entity/association model for this. We must organize different types of information when describing a domain in order to establish a database.

This information must be identified, defined, and arranged according to a given point of view in order to be achieved. We choose to describe the physical components of our legacy as an architectural realization. To be effective, this description must follow specific guidelines. For this reason, we choose to express domain knowledge from a conceptual standpoint. According to the domain's professional members' collective knowledge. The term "conceptual modeling" refers to this type of modeling or representation in a semantic network. The simplification of a domain's conceptual parts constitutes this form of modeling. We've found four elements in this type of language.

- The domain's notions are defined by the entities.
- The existing link between the domain's notions.
- The characteristics determine the concepts' entities or properties.

• The cardinal specifies the number of times a relationship can occur between two notions.

The model's components are as follows:

• Entities: In this example, they represent the domain's notions. They discuss the architectural work and the integration of the environment in more detail.

• The relationship: or the bonds that bind these things together. These connections are diverse. The topological relationship can also be determined. The gallery, for example, is situated "around" the patio. The patio is also in the "heart" of the gallery.

• Entity attributes: define the element from a conceptual standpoint. When describing the elements of architecture, for example, we must include the following elements: shape, material, size, location in space, number, and so on.

• The cardinal indicates the duration of a link between two entities. There is a minimum and a maximum for us. Every element of architecture, for example, has at least one designated space. And multiple architectural works can be found in a single place. In this case, the cardinal is "1, n".

Traditional dwellings are grouped into five families by the entities used to describe them:

• Identify each physical component of the house as an architectural element.

• The spaces: indicate the volume or area that defines the house's functions and uses.

• The materials: these are the materials that were used to construct all of the architectural aspects.

• Urban organization: the structuring of a single realization's spaces in relation to their immediate surroundings.

Environmental integration: represent the elements involved in ventilation, water harvesting mechanisms, ventilation, thermal inertia... determining the relationship between each phrase used indicates a domain idea It's vital to note that the terminology from the original language (local dialect) has been preserved and are used as synonyms.

4. TECHNICAL IDENTIFICATION OF ENVIRONMENTAL FEATURES OF THE CONSTANTINIAN HOUSE

The house no. 93 is a building of traditional type, composed of an "El Ali" which is a commercial part, raised above two stores and a house with a patio. It is a shore house, located on the street Mellah Slimane as shown in Figure 1. It is attached to other houses on its three sides.

The house with a patio in Constantine belongs to the typology of the courtyard house diffused in the Mediterranean basin. The expansion of the shops that face the street, initially independent of the motherhouse, will give their upper level a small house that can be totally independent or functionally linked to it.

Figure 1. Geographical location and facade of the studied house

4.1. The Patio (Wast-Eddar)

The open-air courtyard around which the different components of the house are articulated, temperature regulator, source of lighting, and sunlight, is the space where all the occupants meet, but a feminine space [18] above all.

Wast-Eddar is not assigned to the circulation, a gallery all around that one assures this function, it is considered as the place of the family life, it is where all the daily activities related to the life of the women take place.

4.1.1. Contribution of the Patio to Environmental Efficiency

The Constantinian patio is part of a spatial hierarchy that corresponds to a functional and climatic hierarchy. As for the climatic hierarchy, the rooms furthest from the courtyard have high thermal inertia compared to the rooms directly overlooking the courtyard. The patio ensures throughout the day a quality natural lighting for the rooms surrounding it as shown in Figure 2, in addition to its role related to natural ventilation [19].

The Constantinian patio house meets sociological, cultural, and thermal requirements at the same time. The values of intimacy preside over this conception of the habitat. It is a question of privileging the being, and not the appearance. Thermally, the patio house is particularly well adapted to the hot and semi-arid climate. The patio enjoys a microclimate more temperate than the outside climate, and thus plays the role of buffer space between the interior of the house and the outside atmosphere. Especially in the hot season, it offers thermal solutions that do not contradict the life of the people, their traditions, and their belief system.

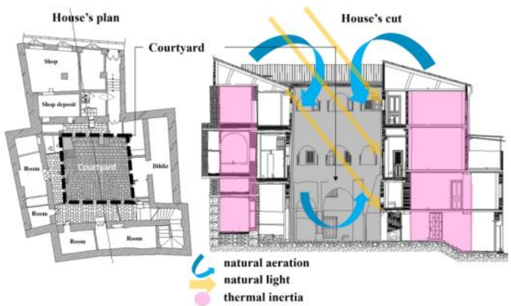


Figure 2. The Constantinian patio at the heart of natural lighting, natural ventilation, and thermal inertia

4.2 The Rainwater Cistern (El-Madjin)

This cistern, built of Roman stone and terracotta brick, accumulates rainwater from the roof and stores it as shown in Figure 3. The house's inhabitants can thus use it in the summer or during periods of great drought, especially since the storage capacity of this cistern is sufficient to provide water autonomy (varying between 100 m^3 and 300 m^3 for large cisterns).

4.2.1. Contribution of the Rainwater Cistern to Environmental Efficiency

Rainwater harvesting from the roof of the house is a sustainable way to enjoy the water throughout the year, which effectively contributes to saving the consumption bill, thus reducing the direct consumption of water supplied by the drinking water network.

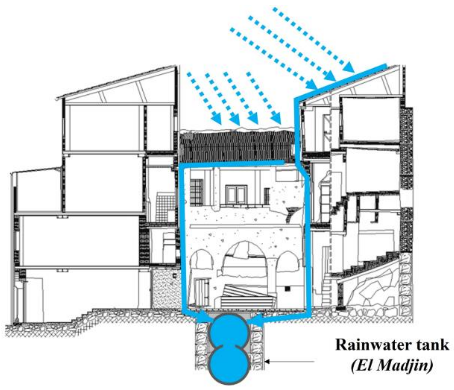


Figure 3. Storage and retention of rainwater from the roof in the cistern (El Madjin)

4.3. The Distribution Gallery (Rwak)

Perceived as the first periphery of the patio that represents the center of the house, is a dynamic space, of irregular geometric form in general, in addition to its functional role, to ensure the articulations between a patio of regular geometric form and a plot often irregulars shown in Figure 4. The walls that define it are ordered. They are generally articulated around an axial symmetry (central door and window on either side). Forming a peripheral path around the patio, it constitutes by the way it integrates into the global spatial composition the possibility to offer a horizontal stroll around the Wast-Eddar but also a moment in the vertical path since it represents a landing in the staircase.

4.3.1. Contribution of the Distribution Gallery to Environmental Efficiency

Unlike the patio, the galleries are covered and act as a buffer space between the patio (exterior) and the interior of the rooms. This gives them a thermal regulating role during both winter and summer seasons. In other words: in summer, the patio attenuates the temperature felt outside, and the gallery in turn attenuates the temperature felt on the patio, this characteristic offers the Constantinian house a natural climatic hierarchy to mitigate the very high summer temperatures.

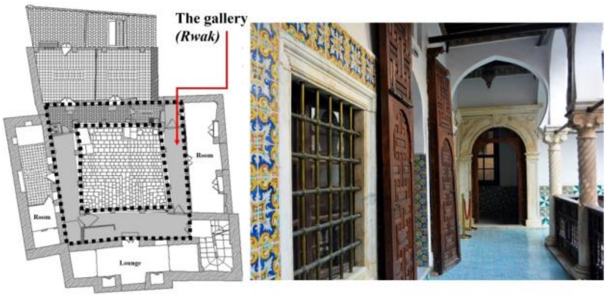


Figure 4. Orientation of the gallery on plan

4.4. Inter-Story Warehouses (Dihliz)

An elongated space of longitudinal shape constituting a void between two superimposed rooms, which serves as a storage space for food supplies. The Constantinian tradition and way of life make that the families store their food called "Awla" to qualify wheat, barley, semolina, couscous, and pasta made by women.

It is a space with a ceiling height of 1m50, which has no windows, but a single entrance door located in the stairwell between two landings as shown in Figure 5, it implies that it is a dark, and slightly cold space, offering an ideal environment for the storage of food and is considered the food cellar of the house.

4.4.1. Contribution of Inter-Story Warehouses to Environmental Efficiency

As these warehouses are located between two superimposed floors and given their reduced ceiling heights, they constitute a void known for its performance related to acoustic and thermal insulation. Thus, playing the role of a real insulating air gap.

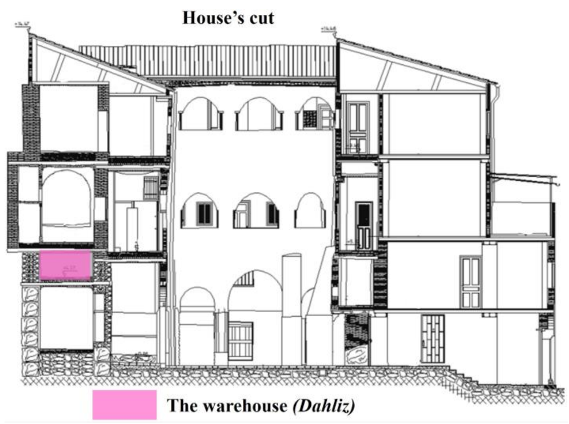


Figure 5. Location of warehouses between floors

4.5. The Chicane Entrance (Skifa)

It is the transition space between the outside and the inside of the house, it is in fact the place of articulation between the family and social life, it is through the Skifa that one reaches the courtyard by an opening placed in chicane to prevent the indiscreet glances as shown in Figure 6, in this space one can receive those which are not allowed to penetrate inside the house, mainly the men, this space communicates directly with another space which is the room of reception reserved to the male guests.

4.5.1. Contribution of the Chicane Entrance to Environmental Efficiency

Acts as an intermediary space between the exterior of the house (street) and the interior (patio), which will give it the character of the thermal regulator, and as an acoustic barrier between the street and the patio of the house.

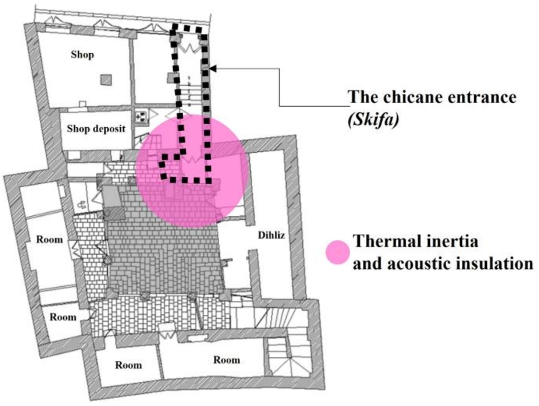


Figure 6. Orientation of the chicane entrance

4.6. The Floors Made of Cedar Wood Trunks (Skef El Arar)

Structural work, made of cedarwood, forms a horizontal platform or a separation between the floors of a building. In the Constantinian house, the wooden structures often concern the floors or the roofs of the terrace: they are composed of logs, on top of which are arranged reeds or battens which will support a mortar of ground and lime as demonstrated by the Figure 7.

4.6.1. Contribution of Log Flooring to Environmental Efficiency

The cedar log floor is a device, which has shown for centuries its resistance, and its ease of execution. The thickness of a cedar log floor of the Constantinian house varies between 60 and 80 cm formed with 15 cm of cedar trunks, 40 to 60 cm of earth, and 10 cm as Chappe, and has a very high thermal inertia, as well as good sound insulation.

4.7. The Adobe Walls (Toub)

Vertical work of variable thickness and height between 40 and 80 cm, formed of superimposed Toub (Adobe) as shown in Figure 8, and bound by lime mortar, and raised over a certain length, having as a role to enclose or separate spaces, to support and bear loads. The Constantinian house also has a variety of walls depending on the use: clay bricks for the construction of structural elements, rubble, stones generally inherited from the Roman civilization, and which are found at the base of the house and especially in the foundations.

We specify that the dried earth brick used in the walls of the Constantinian house is reinforced by vegetable fiber, essentially straw. The adobe walls are generally covered with treated lime to protect them against air humidity and water infiltration.

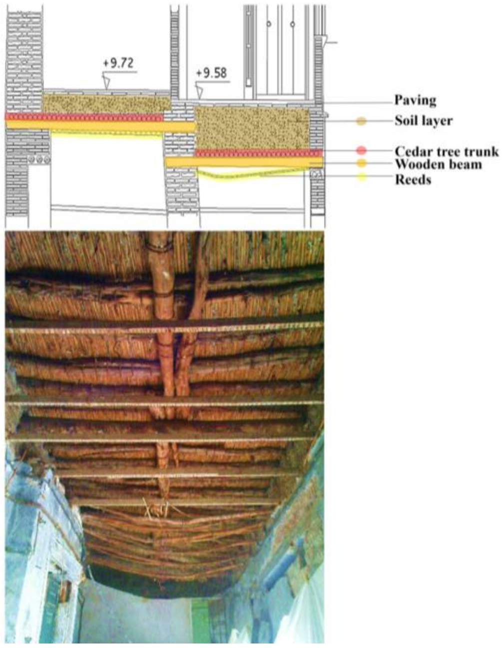


Figure 7. Different components of the cedar flooring

4.7.1. Contribution of the Adobe Wall to Environmental Efficiency

To improve the thermal resistance of raw earth, Constantine's inhabitants have reinforced its insulating power by adding plant fibers: straw, hemp, wood chips, flax, and crushed reed. The earth-straw mixture makes it possible to modulate the density of the walls from 300 to 1300 kg/m^3 to meet the needs in terms of resistance, thermal and/or phonic insulation [20, 21, 22], thermal inertia, and orientation of the wall or noise pollution.

It allows to reach a coefficient of thermal conductivity of about 0.10 W/mK: thus, a wall of 30 cm obtains a thermal resistance of 3 to 3.6 m^{2}K/W. An earth-straw or earth-chip mixture can also be used to fill a wood frame.

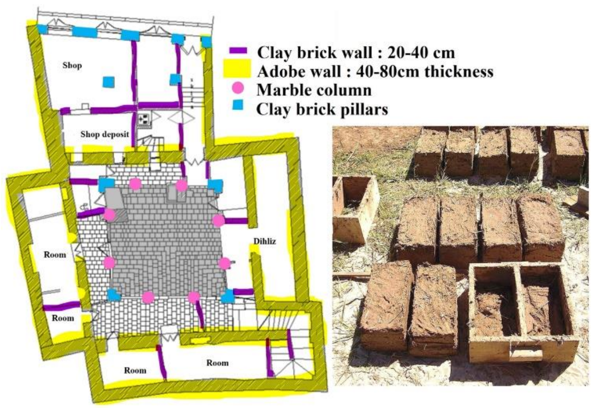


Figure 8. Different building materials and the importance of adobe walls

4.8. The Clay Tile Roof (Es-Kef)

A structure allowing the evacuation of rainwater in most cases, in four slopes, made of red tiles very resistant to the vagaries of time, and in a wooden framework. Three of the slopes open onto the patio as shown in Figure 9.

The whole of the elements which make up the roof, including the framework of the roofs and the cover made generally of a lath covered with tiles manufactured with the old generally by women, and who used their legs like molds, before loading them, which gives them an aspect of irregularity.

4.8.1. Contribution of Clay Tile Roofing to Environmental Efficiency

Constantine's clay tile roofing provides better mechanical and physical protection for the insulation. It also contributes to improving the thermal efficiency of the insulation solution. Finally, it should be remembered that terracotta tiles provide certain thermal inertia and help improve energy performance.

It is estimated that 30% of the energy losses are due to the roofing of houses. It is necessary that the thermal efficiency sought for the roof is effective for a long time, hence the choice of clay tiles [23, 24, 25, 26].

The Constantinian tiles are strong, waterproof, non-combustible, and provide protection against rain and frost. Clay tiles are 100% natural and meet current environmental protection standards. They are guaranteed for 40 years, during which time their appearance will not deteriorate.

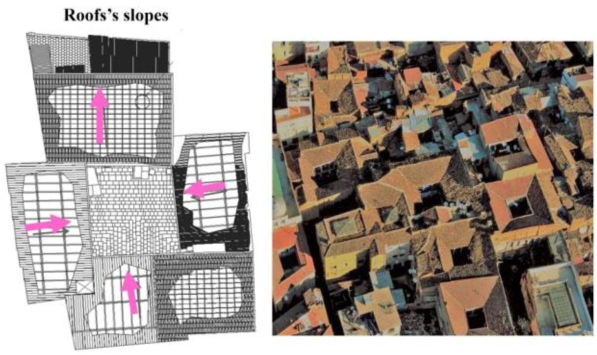
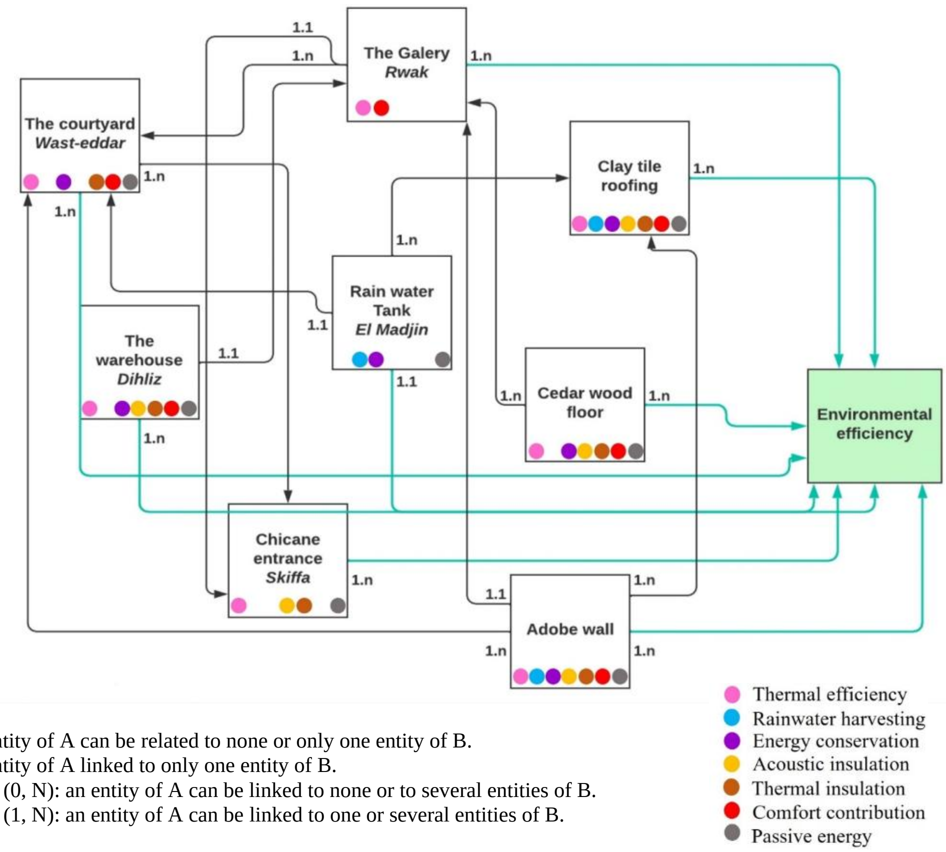


Figure 9. Shapes and slopes of the Constantinian houses' roofs



Associations types:
- From (0, 1): an entity of A can be related to none or only one entity of B.
- From (1, 1): an entity of A linked to only one entity of B.
- From 0 to several (0, N): an entity of A can be linked to none or to several entities of B.
- From 1 to several (1, N): an entity of A can be linked to one or several entities of B.

Figure 10. Conceptual modeling of the environmental devices of a Constantinian traditional house with a patio

5. CONCEPTUAL MODELING OF ENVIRONMENTAL FEATURES OF THE CONSTANTINIAN HOUSE, ACCORDING TO ENTITY/ASSOCIATION MODEL

An entity-association diagram is a form of flowchart that shows how "entities" in a system, such as concepts (rooms in the house), are associated to one another (the Constantinian house). Entity-association diagrams are extensively used in computer engineering [27, 28, 29], enterprise information systems, education, and research to build or debug relational databases. ERDs (Entity-Relationship Diagrams) describe the linkages between entities, their relationships, and their properties using a sequence of predefined symbols such as rectangles, diamonds, and ovals connected by lines. Entities are nouns, and relations are verbs, as in a linguistic structure. The figure below expresses a conceptual representation, modeled in the form of entities and relational associations with "Lucid chart" tool, of the different components of a Constantinian house and their contribution to environmental efficiency.

6. CONCLUSION

In recent years, passive provisions are becoming more and more important due to the policy of environmental protection and energy-saving. The multiplication of buildings integrating these systems leads to a reinforcement of the research works. Many designers are now focusing on the development of systems that meet the requirements of air quality and indoor comfort and are in line with the policy of energy-saving. In this article, we have chosen the conceptual model to define and identify the architectural and spatial concepts related to the environment by limiting our corpus to a traditional Algerian house located in the medina of Constantine.

The conceptual model allowed us to identify some concepts, all of which are related to the integration of the environment. We also found that the materials used to build the house are mostly local and have advanced hygrometric properties to protect and avoid overheating inside the spaces, especially during the summer period. The use of an entity-association model allows too well define all the interactions between the data of the problem [30], between the components of the Constantinian house, and the relationships that link them to each other and their contribution to environmental efficiency.

This study, although less detailed, reinforces the hypothesis that the traditional solutions form good support for the study of the development of a modern housing model better adapted to the harsh climatic conditions in our different regions specially to mitigate the negative effects of global warming in urban areas that have emerged as a major problem that should be faced by local decision-makers.

During the second half of the 20th century, there has been a renewed interest in vernacular architecture: several architects, thermal engineers, and researchers have tried to defend the value of certain vernacular and traditional buildings based on thermal criteria and climatic considerations [31]. We argue that it is the development of what is called the "Bioclimatic approach" in architecture - which integrates the energy input from the climate to explain technical and architectural choices - that has allowed a renewed look at vernacular and traditional buildings. This approach, while developing a more detailed understanding of the thermal behavior of old buildings, has led many architects to reappropriate certain elements and technical choices of the architecture of the past in order to respond to the imperatives of the energy crisis and global warming.

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