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Almayouf, Khaled. Nasef, Otman Elmahdi(Co-Auth)	مؤلفين آخرين:
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Function of the courtyard for adaptability and thermal comfort in a traditional house of the old city in Tripoli, Libya

Abdrahman Faraj Shahrán
Faculty of Engineering Al-Garabulli,
Elmergib University, Libya
E-mail: shahrán_82@yahoo.com

Khaled Almayouf
Department of Architecture & Urban
Planning, Alahlia Tripoli University,
Libya
E-mail: khaled_om73@yahoo.com

Otman Elmahdi Nasef
Faculty of Engineering Al-Garabulli,
Elmergib University, Libya
E-mail: otman.nasef@yahoo.com

الملخص:

منذ بداية القرن الحادي والعشرين ، تمر بلدان شمال أفريقيا بتحول في الأوضاع السياسية والاقتصادية والاجتماعية والحضرية والثقافية. ونتيجة لذلك ، تتغير أشكال المدن والمساكن بسرعة. معظم المساكن المعاصرة غير معدلة بشكل جيد للظروف البيئية والثقافة المحلية ، وتبقى في تناقض مع المساكن التقليدية ، والتي هي أكثر وضوحاً في استهلاك الطاقة. المنازل الجديدة لديها مطالب ضخمة للتدفئة والتبريد ، مما تسبب في الأضرار البيئية الناجمة عن انبعاثات ثاني أكسيد الكربون. تهدف هذه الدراسة إلى إظهار الراحة الحرارية الداخلية في بيوت الفناء التقليدية في ليبيا ، والتي تتطلب تحليلاً يعتمد على فحص حاسم لتصميمها وأدائها الحراري ، وهو ما يؤثر بدوره على رضاء الإنسان الفسيولوجي والنفسي والبيئي. هذه الورقة تقيم وظيفة الفناء للقدرة على التكيف والراحة الحرارية في المنازل التقليدية في المدينة القديمة في طرابلس. والقصد هو تقديم تحقيقات في القضايا المناخية إلى جانب الجوانب الاجتماعية والثقافية للتصميم التقليدي وأدائها. وبالتالي ، فإن هذه التجارب سوف تساعد في تحسين الظروف الحرارية المستقبلية للإسكان الفردي في ليبيا.

الكلمات الدالة: الراحة الحرارية، الفناء، الإسكان التقليدي ، التصميم المعماري ، المناخ.

Abstract:

Since the beginning of the 21st century, the countries of North Africa have been undergoing a transformation of political, economic, social, urban, and cultural situation. As a result, the forms of cities and dwellings are rapidly changing. Most of the contemporary housing is poorly adjusted to the local environmental and cultural conditions, remaining in contrast with traditional housing, which is most obvious in the consumption of energy. New houses have huge demands for heating and cooling, thus causing the environmental damage by the emissions of carbon dioxide. This study aims to show the internal thermal comfort in traditional courtyard houses in Libya, which requires an analysis based on a critical examination of their design and thermal performances, which, in turn, has an impact on human physiological, psychological and environmental satisfaction. This paper assesses the function of the courtyard for the adaptability and thermal comfort in traditional houses of the old city in Tripoli. The intention is to present an investigation of climatic issues together with the socio-cultural aspects of traditional design and their performances. Consequently, those experiences will help in improving the future thermal conditions of individual housing in Libya.

Keywords: *Thermal comfort, courtyard, traditional housing, architectural design, climate.*

1. Introduction

Contemporary housing projects encourage the use of expensive imported ingredients, and because of that, they have become dependent on the import of building materials and infrastructure components. Additionally, the buildings constructed using those materials are not suitable for the climatic conditions of the region. Libya, like most developing countries, has experienced a rapid growth in the construction sector during the last thirty years. Unfortunately,

this growth was only in favour of “modern” construction, which gave rise to a large number of uniform-type reinforced concrete structures being built all over the country, with practically no regard for the conditions prevailing in their vicinity, both climatic and cultural. This resulted in not only uncomfortable and energy-consuming buildings, but also in severance of ties with the historical past and culture of local people. Traditional housing in Libya designates the common, non-scientific pattern of residence. It is an indigenous building style using local materials and traditional methods of construction that is important element of preservation of the cultural housing heritage. However, traditional Libyan housing form assumes a compact settlement outlook where the courtyard system is fitted within a spatial hierarchy, in response to light, thermal needs and ventilation, both physically and socially, to enable the extended family dwellers and to guarantee mutual privacy. Socio-cultural value is also an important parameter to be considered in this context. There has been an effort to maintain the continuity of the cultural identity of the old city in Tripoli by retrofitting the existing façades, but unfortunately, there was no intention to improve the quality of the indoor environment of buildings. Various researchers confirmed the importance of thermal comfort for both living and working satisfactions and behaviour (Amasyali and El-Gohary 2016; Wang, 2016), within the concept of energy efficiency that has a significant influence on reducing the energy consumption and improvement of environmental conditions.

2. Overview of geographical factors of the coastal region (Tripoli) in Libya

In Libya, natural conditions have influenced the built environment to a great extent. It can be observed in the physical structure of buildings, land usage, and distribution of population. About 94% of the total area of Libya is a desert, most of which is considered to be

unproductive. About three-quarters of the population are situated in major urban areas and most of the cultivated land is concentrated in less than 2% of the country's total area (Ministry of Municipalities, 1979). The topographic features vary throughout the country and include plains, mountains and the desert. Settlements are located along the coast in the North stretching from the east to the west borders of the country. The coastal strip varies in width from 15– 45 km, tapering close to the “Green mountain” (Jabel-Akhder) and expanding to 100 kilometres in width before the western mountain (Jabel Nufusa), forming the Jefara Plain of the northwest Libya (Philips, 2000).

Tripoli region is geographically situated in the north of the Equator, at 32 degrees longitude, and 13 degrees latitude east of Greenwich. Tripoli area is considered to be the most important planning province in Libya, as it is the largest populated region. The surface area reaches 225,282 km² (Altumi, 2001). It represents about 12.8% of the country's total area. Tripoli is the most important city in the province and the country as well as the social, economic and cultural centre, and the major attraction for population migrations inside and outside the province.

3. The traditional Arabic courtyard house

The traditional courtyard house is one of the most common building typologies and significant element of urban morphology in the historic cities in Libya with holistic design materials and techniques strongly related to the cultural and environmental tradition (Atmansuri and Curwell, 2009 ; Abufayed and Rghei, 2005). It can be found in all Arabic cities, just as it can be found in all Mediterranean countries. This building typology is characterized by a small number of relatively little openings in the external façade, and a large number of openings that overlook the inner courtyard. Traditional houses vary in size and luxury level, and inner spaces vary in number and size

from house to house, although they all have one common feature: the open courtyard that gives the occupant a feeling of privacy and privileges the relations between the individuals of the family, who consequently develop a strong attachment for the house. The inner courtyard is a garden and the centre of household activities: all the rooms are set around it and open onto this gathering place, as shown in Figure 1. In large and medium sized houses, a fountain is placed in the centre of the courtyard, refreshing the air; trees are also grown in many traditional courtyards, adding shade and life to this exclusive area. Generally, the living rooms and service rooms are on the ground floor, whilst bedrooms are on the upper one. In large houses with more than one courtyard, spaces are separated into an area for the owners of the house, another one for guests and a third for servants.

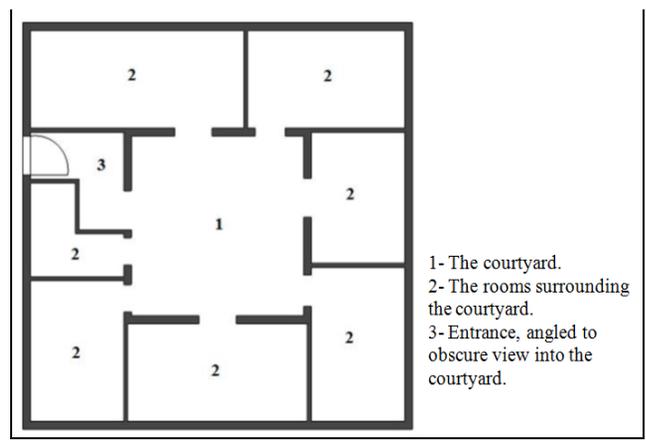


Figure 1: A plan of a traditional house in the old city of Tripoli, Libya.
4. A case study of the courtyard in a traditional house in Tripoli, Libya

The old city of Tripoli is situated on the coast and was surrounded by the wall until the 20th century, when substantial developments occurred outside the city walls under an Italian town-planning scheme. Two traditional neighbourhoods are Bab el-Baher and Hornet

Geerian, representing traditional housing built during Islamic and Ottoman periods. The old city has experienced development and yet still has enough traditional houses left to provide needed information about thermal comfort. The case study house is located in the north-eastern part of the old city, in Tripoli, near the sea, 7 m above the sea level, in Al Hara al Kebir Street, near the ancient summit Hotel, across the Arch of Marcus Aurelius. The house is surrounded by others on both sides, and from the front and the back with the street and alleys. It was built during the Italian colonization of Libya, in 1945. The total house area is about 450 m², and plans are shown in Figures 2 and 3.

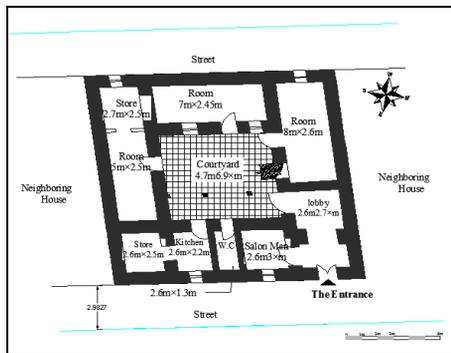


Figure2: Ground floor plan of the house.

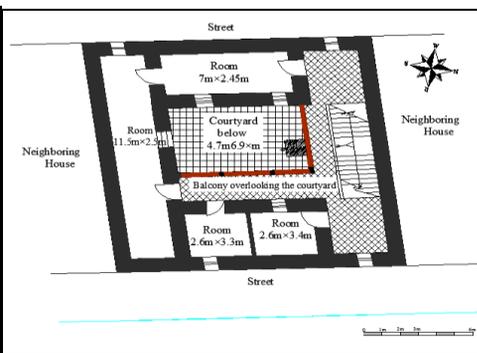


Figure3: First floor plan of the house.

4.1 Climate of the location

The climate of Tripoli, with an average rainfall exceeding 70 mm per year, has an average temperature of 8°C to 36°C in winter. In summer, it is hot and dry, with an average temperature of 28°C to 45°C. The largest percentage of people in Libya lives in this zone, covering the whole Libyan coastal area, where the climate is more comfortable. The urban fabric of the old city of Tripoli is compact, as the buildings share two or three walls with the neighbouring houses; thus, the exposed surface is minimized. In addition to the narrow

streets that provide shading almost all day and protect the buildings' vertical wall surfaces from the direct solar radiation, most of the main streets run from the northwest to southeast and northeast to southwest. This protects the city from the undesirable south wind in the summer, and causes it to be oriented towards the desirable sea winds (Gabril, 2014).

4.2 Urban situation

The street pattern of the old city is ancient, dating from the Roman period and being developed during the Arab, Ottoman and finally Italian periods. In addition to archaeological factors, the street network of the old city has been influenced by the topography. Clusters of courtyard houses form the main component of the urban fabric, with a building density of 48 buildings per hectare.

The courtyard house layout generates a dense urban fabric, showing a clear separation between the public and private open spaces. Magda Sibley pointed out that “the courtyard houses of North African medina’s display different characteristics than those of Egypt, Syria and Iraq as they feature the most formalized configuration with an absolute centrality of the courtyard”. The analysed house is built around an almost square-shaped courtyard, in an irregularly shaped house. The house has only one façade facing the narrow covered street. The width of the street is nearly two meters, and the other sides of the house are attached to other houses. The streets are characterized by arched, flying buttresses built over narrow space to support the building walls, to provide shade, and to create spaces for social interaction, as shown in Figure 4.



Figure4: *The corridor area maintains the varying air pressure (high and low). The gallery is associated with cooling air currents within the space.*

In the case study house, thermal comfort is affected by several factors, like building orientation, ventilation, and shadowing, although the size of the land, to some extent, is influential as well. The average size of this courtyard is determined according to the latitude. It is narrow enough to maintain a shaded area during the heat of the day in summer, but wide enough to receive solar radiation in winter. The elements of the courtyard comfort evaluation are as follows:

4.2.1 Building geometry and orientation of the courtyard

According to climatic conditions for each district, specifically related to prevailing winds and the movement of the sun in the area, a building takes certain geometry. Factors which are considered in designing a courtyard are the following:

- Ensuring the natural light for interior spaces in the house in desired times;
- Suitability for humidity by ensuring ventilation, where we note in this house that most windows open outwards. Especially on the higher floor, these windows are directed to the northern/south orientation in

order to enable the penetration of ventilation air to the interior spaces and to reduce undesirable sun rays.

In the case study house, the amount of solar energy absorbed within an urban space, such as a courtyard, during a given period, is determined by the penetration of shortwave radiation into the space and by the albedo of the entire system. Although the latter is considerably a function of material reflectivity, both factors are affected by the orientation and geometry of the courtyard.

4.2.2 Cross ventilation of the courtyard

Continuously ventilated conditions are essential in a hot-humid region, since that can remove the heat and humidity from the building for achieving comfort. The design of the building is suggested to be such that promotes maximum air movement with less internal obstruction. This traditional house is one of the examples. It has a raised marble floor with multiple window openings on the building's façade to achieve the necessary cross ventilation condition. That secured, only cool air flow into the indoor spaces can provide a better indoor thermal condition. This condition can be achieved by the application of cross ventilation with low heat absorption materials in the courtyard, or by utilizing the night ventilation strategy. A cooler courtyard floor helps remove the heat from the incoming air to the building during the daytime, while utilizing night ventilation that can induce cooler outdoor air into the building during the night-time. Hence, the consideration of the thermal condition of the incoming air is also important to ensure that the increasing of air flow rate is consistent with the reduction of building thermal condition.

4.2.3 Shadowing

In the hot-humid climates, direct shading seems preferable. The reason is in the fact that the shading effects provided by the building orientation have less effect on the courtyard thermal condition in comparison to the courtyard with a covered roof.

Traditional houses are usually surrounded by a wall on the roof, around an interior courtyard. During the day, interior and exterior spaces pass through different shadow periods, and the courtyard represents a source of natural lighting for the surrounding rooms. This area is not exposed to the sun's rays even in hot periods, due to the available trees in the interior courtyard that create equilibrium in the internal environment of the house. This courtyard permits the removal of hot air and the maintenance of cool air inside the courtyard; it also preserves the coolness of surrounding spaces. Also, in the case study house, shadowing has been additionally maintained with the applications of the courtyard's veranda and the canopy of trees. The direct shading methods using shading devices provide better horizontal protections from the high altitude of sunlight. Figure 5 below shows the thermal value of the courtyard in enhancing the cross ventilation through shadow casting.

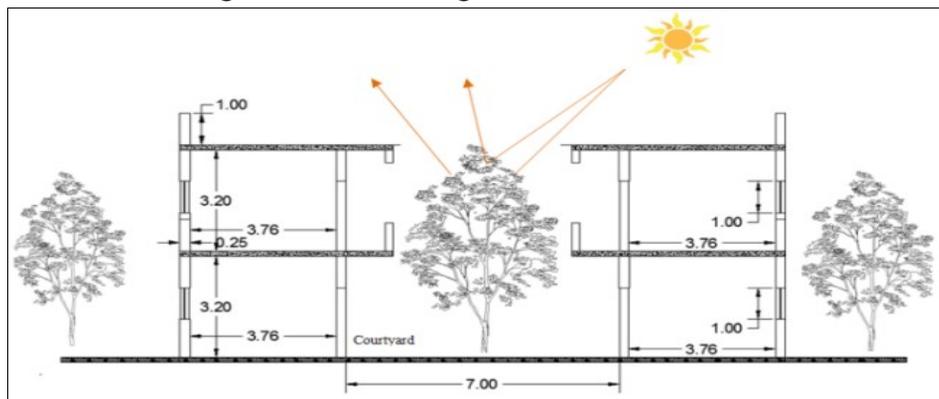


Figure5: *Types of natural elements for shadow in the courtyard of the case study house.*

5.Results and Discussion

The traditional Libyan courtyard house is possibly one of the most enduring and wide spread housing types in history. It is found in antiquity and in modern times, in most world regions, in different climates and cultures. The fundamental research issues tackled was the extent of function of the courtyard for the adaptability and thermal comfort in a traditional house in Libya. Thermal comfort in the case study shows the adaptability of a traditional Libyan house form for natural environment. The traditional strategies should be examined and advantages of those approaches should be taken in the future. The thermal performance of the courtyard house in the old city of Tripoli demonstrates a noticeable reduction in summer heat by using local materials, lime blocks and palm wood, along with vernacular cooling and heating techniques such as orientation, thermal mass, opening location, layout context and adjustable shading devices to obstruct solar radiation in warm seasons.

6.Conclusions

In the traditional house in the old city of Tripoli, social and climatic factors influence the formation of the specific type of the house. The structural system is simple and it relies on the load-bearing walls that are very thick to resist high temperatures. The design of the house is in the row form, so that the interior spaces are protected from the hot sun rays. Traditional houses are thought to be more adequate for the climate because of the characteristics of the materials used; likewise, a use of local building materials with the purpose of providing thermal comfort to residents is an example which needs to be used as a sample of sustainable housing. As can be seen, the major

strength of the traditional design is that of improving the thermal comfort and minimizing the energy consumption. Cross ventilation is enhanced through openings and their locations, size of the courtyard and orientation. Others factors are temperature, humidity and air velocity, availability of shades, size of the courtyard and building geometry. Courtyard house has been one of the fundamental factors to meet human demands for thermal comfort.

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