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Climate Effect on Architecture: A Comparative Study Between Climate-Responsive Architecture of Iran and Egypt

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ABSTRACT

Vernacular architecture has not been developed only due to the climate and environmental factors, but the culture, traditional materials and morphology (morphology) have been also effective. Despite the huge gap that exists between Iran and Egypt geographical locations, identifying similar native strategies influenced by Persian and Arabic culture and desert climate are possible. This paper presents a comparative study which investigates the patterns of sustainable architecture and passive strategies in both countries' architecture. This comparison includes the design and planning, environmental recognition, construction materials, spatial analysis, and the effects of history and culture. The results of this research will help in understanding the passive solar strategy applied in both countries. Also, a set of proposals for the study of energy efficiency are presented.

Key words: Vernacular architecture, Comparative analysis, Sustainable architecture, Urban layout, Passive strategies.

INTRODUCTION

Desert with a huge domain of areas and different cultures displays various magnificent architecture styles. Desert vernacular architecture which is appreciated as a model for sustainable architecture and energy efficiency, In fact, has been created by the result of a collaborative effort considered local constraints and available resources. Vernacular architecture is a type of construction that can be used as a model in terms of stability, as the goals which are the basis of sustainable construction are derived from the components of this architecture (Cardinale, Rospi *et al*, 2013)**.**

One of the vernacular architecture specifications is balancing the harsh climate with traditional technology, which is the biggest characteristic and the lack of reliance on non-renewable energies. This type of architecture does not require special technical equipment which makes it suitable model for the contemporary construction. However, some of these techniques due to some limitations such as constantly climate change and limited resources and available materials are challenged by contemporary theorists (Fernandes,Silva, 2007).

It was tried to specify the role of these historical techniques which have environmental and cultural sustainability in their designs (Martín, Mazarrón *et al*, 2010).

METHODOLOGY

This paper presents a qualitative approach through exploratory and comparative analysis of the strategies which are used in the vernacular architecture. Examples of north of Egypt (near the Mediterranean Sea) and the center of Iran (Yazd city) were given. Comparative study formed systematically which emphasized on passive strategies, especially cooling passive strategies (due to the desert climate) to understand the similarities and differences

between two regions.These analyzes will be the guideline for the current and future designs and will be considered as a guidance key for qualitative surveys in passive strategies.

Climatic characteristics determination of Iran (Yazd a city in Iran) and Egypt:

Yazd geographical location and its proximity to the dry and salty desert has caused severe temperature fluctuations that occur in this region, So that the temperature difference between night and day and in different seasons is very high. Maximum temperature 46 °C and minimum temperature -20 °C have been recorded (Pirnia, 1371). Yazd region is surrounded by mountains, far from the sea. Limited rate of precipitation rate, low relative humidity, high temperatures and intense evaporation (the highest evaporation of 4200 mm per year is recorded) are its climatic specifications (Ayati ,1941).The combination of these factors has made the Yazd one of the driest regions in Iran (Afsharsistani, 2000). On the other hand, Egypt has a hot desert climate. The climate of the northern part of Egypt is a Mediterranean climate which is quite different from the rest of the desert areas of Egypt. Prevailing winds that flow from the Mediterranean sea temperate northern coastline weather effectively and bring about hot and humid summers; while the winter weather is humid and temperate (EMA, 2013).

The minimum monthly mean air temperature in wintertime is 9.5 C° and in summertime is 23 C°. However, the maximum monthly mean air temperature in winter is 17 C° and in summer is 31 C°. Annual mean precipitation rate is about 200 mm (EMA ,2013).

Climate -responsive strategies used by indigenous Mediterranean architecture

Mediterranean vernacular architecture has been known and organized practically as an effective, sustainable and climate-responsive architecture (P. Oliver ,1998). In the past, the energy was not available like today; the active systems were not available, Manufacturers had to test and develop innovative systems resulted in the thermal comfort of the residents and were the respond to the special needs of humankind and climatic conditions through available resources,(P. Oliver ,1998); (Turan ,1990); (Nichols, 2012) ;(Fernandes, Mateus, 2012).

DISCUSSION

Despite of distance between Iran and Egypt and their different locations, gaining common items regarding the passive indigenous strategies which are used in both countries is possible.

Architecture in both countries is heavily influenced by the local climate, but also the Persian and Arabic cultures strong impact is obvious in the architecture. As Table 1 shows, the used strategy in the two regions and their goals are very similar. Some of these strategies are discussed below.

Direction and urban layout of buildings

In urban scale, using the compact layout for these areas, with hot summer periods, are better than modern orthogonal designs and extensive street networks.

A compact urban structure or building cast more shadows between buildings and minimizes heat absorption in summer and reduces indoor heat loss in winter. In, narrow streets and hallways or covered corridors in buildings are integrated, and crossing through these structures is much easier for pedestrians, as they cast shadow on pedestrians and reduce the wind speed, especially in the wintertime (Koch-Nielsen, 2002). The sinusoidal streets act like a yard at the urban scale and high-speed cool air flow at them nocturnally, and cause air to flow in the streets during the day. Early morning, due to the high thermal inertia, walls and sidewalks remain cooler than the surrounding environment. Public green areas (parks) are also useful for reducing the urban heat island impacts and enhance the thermal comfort of urban space. (10% of the solar radiation is absorbed by green space while 65% of the radiation is absorbed by sidewalks) (Koch,Nielsen, 2002).

Building orientation depends on site conditions, such as topography, so the architects try to locate the buildings close to the standard orientation. As Table 1 shows, the covered entrance facing south is much more common to absorb less solar radiation during the summer and more solar radiation during the winter. However, to minimize the direct solar radiation absorption, placing the openings in the eastern and western facades is forbidden. In detached and isolated buildings,

backside facades are oriented to the South in order to catch more cooling and prevailing winds.

passive cooling and natural ventilation

In building scale, similar passive cooling strategies are as follows:

- Using yard to minimize the surfaces that are exposed to sunlight and making maximum shade and ventilation.
- Using plants in the yard to increase the air cooling potential
- Using heavy thermal mass and compressed building materials, such as soil and rock, with high thermal storage capacity to adjust and regulate the heat fluctuations.
- Using bright colored stones to reflect the solar radiation.

Some elements exist in historical yards which have cooling role and belong to Persian and Arabic architecture inherently. The use of vegetation and water-related elements has a significant impact on building micro-climate. An experiment conducted in the summertime of Portugal proved that the mean air temperature in the yard is always lower than the mean air temperature in center central business district (CBD), so the difference even reaches up to 9 degrees centigrade daily (Fernandes and Silva ,2007).

Another experiment conducted in Egypt showed that the yards which have capability of shading too, have mean air temperature between 5 to 8 ° C lower than the mean air temperature of the adjacent streets (Dabaieh, 2011).

The reason behind this difference lies in evapotranspiration of plants, shading and water vapor released from ponds which results in release of latent heat and cool down the air temperature consequently.

Table 1: Climate-responsive passive strategies which have been used in vernacular architecture in the north of Egypt and center of Iran

Urban layout and the construction shape
• Compact urban layout reduces the number of surfaces which are exposed to solar radiation.
• Narrow streets , indoor covered lanes and sidewalks which have been protected from the harsh summer heat (has been capped).
• The compact construction and yards are abundant features in urban areas. The direction of the buildings has been made to the south to maximize the efficiency of sun light absorption in winter, and minimize the sunlight incidence in summer.
Use of shading and natural ventilation
• Casting shade properly by using the curtains or plants (mat) when the thermal efficiency is not desirable.
• Using the nets to promote air circulation in the building to ensure the privacy and thermal comfort.
Small windows
• In order to reduce the heat absorption, minimize the size and number of windows and vents.
Cooling off by the fountains and ponds
• To make the air cool by water evaporation, fountains and ponds are usually placed in the yard or hall.
Use of plants
• plants (trees) are used to provide shade and increase air moisture through the vapor transmission process and will make the air flow cool before reaching the building.
The use of indigenous materials, mainly the soil
• The use of local materials, mainly rock and soil are suitable for native climate. Their good thermal storage capacity provide a stable temperature inside the building (are cooler during the day and warm at night).
Building Painting
• Using bright colors to cover the buildings, especially the roofs, which are most exposed elements to sunlight and the bright colors as the Albedo (high reflection coefficient) reflects sun rays and prevents from heat absorption.

Natural ventilation to cool the building nocturnally is an important and useful passive strategy in hot climate. During the night, through the use of the night flush effect, circulation of air in the building is possible to release the stored heat during the day and provide more thermal comfort for residents without disturbing their privacy or compromise the level of their security.

The building envelope and construction materials

Building envelope is the most exposed element to solar radiation. In order to reduce the sunlight absorption, openings are retreated into the facade to make more shade, so light colors are used too. Applied color to the facade has significant influence to reduce sunlight absorption and consequently reduce the indoor temperature (Givoni, 1994).

Therefore, painting by traditional plastering is an important element against severe solar radiation absorption and reflect the incident radiation about 90% (Koch,Nielsen, 2002).

Regarding the materials, rocks and soils (mainly crushed or clay soil) are main construction materials in both regions. Dense mass that is the property of brick and stone makes the building capable to resist easily against the scorching summer sun. Several papers discussed the thermal storage capacity of soil and rock and how they regulate temperature and humidity inside the buildings (Minh,2011); (Siegesmund,Snethlage, 2014).

Many studies focus on how the indoor spaces made of adobe and stone stay cool daily and release heat nocturnally; contrary to concrete which traps heat and raises the air temperature of the building drastically to an unbearable level (Kennedy, 2004);(Mäckler, 2004).The other advantages are that the rock and soil can easily be recycled, either by reusing the old stone blocks or clay bricks as building materials or returning them to the soil in order to grow and cultivate the plants.

Using local materials caused more compatibility with environment, more sustainability and economic saving. Furthermore they have less negative impact on the environment compared to the other materials.

Industrialization of construction techniques and extensive use of artificial air conditioning systems have destroyed the diversity of architectural forms and made them similar together all over the world. In this situation, industry section doesn't care about environment which results in to more energy consumption and subsequently negative effects on the environment.

Therefore, we need to learn technical knowledge to use passive and indigenous traditional technologies in the contemporary era. Thus, this study introduced the traditional passive methods which could be found in forms of climate-responsive architecture.

Thus, localization is not only application of successful patterns of climate-responsive architecture, but also getting to know with traditional manufacturing, value engineering, coming across with environmental constraints, such as restrictions on the supply of materials and respect for the traditions and cultures, too.

Vernacular architecture can reduce energy consumption and waste through the use of passive solar systems and local materials.

The construction techniques were used according to the needs of buildings. In addition, climatic characteristics of the region have been considered when the techniques have been applied (Kimura, 1994);(Singh, Mahapatra *et al*, 2011).

CONCLUSIONS

It seems that people have accepted that climate should be considered in the design of buildings.

But practically, our contemporary designs are heavily dependent on fossil energy over the life of the building because of their association with mechanical devices to control the micro-climate inside the buildings. But this approach has many disadvantages: not only increases the initial construction cost considerably, but their periodic

maintenance costs are also very high. This study showed that although many traditional buildings exist still in the desert, but the integration of traditional architecture as a compiled set in order to use in contemporary modern architecture and make it sustainable is still challenging but desirable. It seems inevitable that instead of relying on the tools and gadgets, the architect must learn about indigenous passive strategies and draw its efforts to control the micro-climate inside the buildings with minimum energy and natural techniques. Thus, mechanical systems and active devices can be auxiliary and activated only when the natural resources does not provide the thermal comfort of residents.

By learning from the past, future residents can take advantage of existing and potential technologies to change the current energy consumption patterns. In many cases, an indigenous structure may be unsuitable due to the current standards of comfort, but it can offer clues about strategies which can reduce the use of renewable energies. Through the optimization of these strategies, we can meet the standards of comfort and reduce the use of fossil fuels simultaneously.

The results of this study proved indigenous climate- responsive solutions that can be used as an approach to improve the energy efficiency of modern buildings. The following issues for further research should be considered and are recommended as below:

- Comprehensive Studies and surveys in order to adapt the local passive strategies with contemporary architecture, especially after the recent climate change are needed.
- The effective local strategies should be used as contemporary and urban design guidelines for building design codes.
- Vernacular Architecture of Iran (after verification and testing of simulation in each region) can be applied as a model for contemporary design in buildings used in all desert areas.
- For this moment, we have no national documentary reference about the use of passive strategies in both countries. Provide a reference and document for contemporary architects can encourage them to use these techniques as sustainable patterns in their designs.

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