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ANALYSIS BUILT FORMS OF COURTYARDS IN ARIYALUR CONTEXT TAMILNADU, INDIA.

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ABSTRACT

The first courtyard houses across worldwide reference according to the historical evidence provided, appears to be originated probably around 6500-6000 BC, the best evidence will be the earliest village from Mehergarh. Paul Oliver wrote in his book Dwellings: "The House Across the World" says that, "Courtyard houses have an ancient history: examples have been excavated at Kahun, in Egypt, are believed to be 5000 years old, while the Chaldean City of Ur, dating from 2000 BC, was also houses of this form". But the precise evolutionary path is still remains undetermined. The courtyard's configuration will be always varying according to the typology of the spaces around the courtyard. The courtyards always tend to show different characteristic features along with varied cultural, economic, social, psychological aspects of the society, location and also climate. This research paper proceeds understating the role of the courtyard in providing comfort levels in terms of ventilation, lighting, thermal comfort and also indoor air temperature. The objective of this study is to understand the courtyards in terms of sustainability by analyzing the historic evolution of the courtyard forms, elements through site specific studies, with the typical example of 75 years old house in Ariyalur, Tamil Nadu.

INTRODUCTION

Though hybridization and metamorphosis of architecture and society is taking place day by day, there has been a good flow in the

vernacular buildings. In the evolving range of the architectural styles in India, there has been one trend that has continued to be expressed in the field of architecture– the courtyard type. At present the courtyard forms may be alive but not growing and also been replaced by many Westernized-box architectural types in India. Randhawa, 2005 says that courtyard types have been historically not only a style of architecture but also a "way of life", coated with the reference to the residential architecture in Indian context.

The simple definition of the courtyard is it is the opening to the sky that is present inside a building. It is one of the most efficient features of the traditional houses of India. Researches on courtyard houses in the traditional societies have already proved to be useful in the contextual level which responds to the cultural and the climatic response. Courtyard has gained a proper identity in the residential planning in India started from the past till now. The ideology of the courtyard is handed over from one generation to another generation as a cultural heritage, symbolically or conceptually (Lee, 2015). Since certain psychological, biosocial and cultural characteristics of the human beings continue to be influencing certain characteristics of the built environment throughout the past, courtyard survived in the history and also continuing to be acknowledged in the field of architecture.

TRADITIONAL COURTYARD BUILDINGS

Hatamipour and Abedi (2008) have shared some useful passive cooling systems from ancient Bushehr architecture of Iran for natural cooling of buildings in a hot and humid region. These technologies are used for several years for protection of people from harsh summer conditions and made the people to live in comfort without the use of any electrical air conditioning systems. The technologies and controls for solar passive cooling of buildings include: suitable insulation of walls and roofs, reduction of heat gain through walls by light coloured surfaces, small windows and mutual shading restricting heat gain through windows, use of louvers for natural ventilation, orientation of building along wind direction, cooling storage by use of heavy walls as thermal mass, use of overhang for shading using wooden sunshades and shading of buildings using trees. Separation of heat generating spaces, construction of high roofed buildings and providing adequate windows are other solar passive techniques listed out which can be used today for the thermal comfort of modern buildings.

Abdul Manah Dauda (2016) compared the traditional and modern Architecture in Ghana. The measured temperature in traditional indoors varied from 28-35 ˚C and in modern building it ranged from 31-37 ˚C.

The maximum Mean Radiant Temperature (MRT) is found to be 4-5 ˚C less in traditional building and 3 ˚C higher in modern building than the corresponding indoor air temperature. In traditional building the roof is made of the thatch; ensuring well ventilated membrane with pores in between. This offers high insulation and allows hot air to escape. Modern house has corrugated metal sheets allowing heat, increasing air temperature and thermal discomfort. Effective passive and natural control system in traditional building provides a thermal comfort more than modern building.

Susanne Bodach et al. (2014) studied the climate responsive building construction and design strategies of vernacular architecture in Nepal. The design recommendations suitable for Nepal were identified using Olgyay's bioclimatic chart, Givoni's psychometric chart and Mahoney table. From the study of vernacular houses of Nepal, it has been reported that solar passive heating for winter, high thermal mass, large roof overhang to keep summer sun away, enhanced air movement and medium sized windows in summer, arrangement of courtyards, shaded semi open spaces like balconies, verandas and courtyards providing cooler spaces in summer used in vernacular houses of Nepal provide thermal comfort and hence, these techniques can be followed for modern constructions.

Megha Jain and Singh (2013) studied the solar passive architecture concepts and techniques incorporated in the design of a heritage building - Gohar Mahal in Bhopal. The building was built in 1820 with passive design concepts applied by our ancestors. Various solar passive design considerations and elements incorporated in the design of Gohar Mahal includes landscaping, water bodies, orientation, site features, open spaces, built form and envelope design. Field measurements which are taken at strategic locations within the building are compared with outdoor conditions. The parameters measured include temperature, humidity and air movement. During summer, it is found that the indoor temperature is below 26 ºC. The study inferred that the thermal mass and the envelope design in the building contribute to the indoor microclimate, stabilizing the indoor temperatures and giving thermal comfort.

Manoj Kumar Singh et al. (2014) reported on design optimization of vernacular buildings using solar energy modular simulation tool TRNSYS 17 using 3D models with three types of construction and eight possible orientations in warm and humid climate of North-East India. Parametric simulation for different types of scenario such as orientation,

wall thickness, thermo-physical properties, window glazing type, window to wall ratio, shading, infiltration, ventilation, internal heat load and false ceiling types are carried out for design optimization. In the recent years, the energy consumption has increased in vernacular buildings though they are naturally ventilated due to the quest for better thermal comfort. Hence, the simulation objective of improving indoor thermal comfort or reducing the number of discomfort hours. The results suggest that large openings in windows and ventilators promote cross ventilation. It is also found that the heat gain is more during summer due to infiltration. Hence operating windows and ventilators and promoting night ventilation is recommended. Window replacement with double glazing and proper shading elements has shown improvement in indoor thermal conditions. Further analysis revealed that the vernacular building is more comfortable in pre-summer and pre-winter season.

Usha Bajpai and Sachin Gupta (2015) highlighted the solar passive concepts used in Avadh Architectural buildings in Lucknow, India. The passive concepts incorporated in the tomb such as high roof, curved roof, natural ventilation, massive thick wall and openings: light coloured exterior to reduce heat gain into the buildings are widely found. The height of the building is around 10m. This type of construction allowed warm air to collect at top and such stratification of warm air at top maintained cool place creating a comfortable zone. It is observed that U-Value of the wall is low due to very thick wall. It is also observed that usage of water and landscaping influenced the micro climate inside and around the building.

Manoj Kumar Singh et al. (2010) reported the thermal performance evaluation of comfort temperatures in vernacular buildings of North-East India. 50 vernacular dwellings with 100 inhabitants was taken for the study during winter, pre-summer, summer/monsoon and pre-winter in the months of January, April, July and October. The time lag for the heat transfer in the house is 5 to 6 hours which show high insulation value. Window to Wall ratio is found to be 0.216. Sufficient number of doors, windows and ventilators are provided for adequate ventilation which accounts for about 50% of the floor area (openings). Maximum temperature swing inside the house remains 10 ˚C which is quite good for naturally ventilated traditional buildings. It is also concluded that the day lighting inside the building is insufficient.

Praseeda et al. (2014) have assessed the impact of material transition during retrofitting of a naturally ventilated traditional building at Sugganahalli near Bangalore for thermal comfort models on Embodied Energy (EE) and Operational Energy (OE). ASHRAE comfort standards

and TSI model by Sharma and Ali are used. Results show that traditional buildings consume less operational energy even in extreme climatic variations as they use passive techniques or non-mechanical methods for space conditioning. It is reported that by changing material, EE is increased.

STUDY AREA

Ariyalur is considered as one of the important places in Tamil Nadu. There are numerous lime stone mines and about 9 cement factories located in and around Ariyalur. Ariyalur is located 250kms south west of Chennai and at about 60kms from Trichy towards northeast.

Ariyalur has witnessed an unusual phenomenon of increasing sea level before 120 million years ago. The area extending over one lakh hectares comprised, what is the presently called Jayankondam, Andimadam, Kolakkanatham, Dalmiapuram, Sathanur, Kunnam, Sendurai, Ariyalur and Keezhapalur villages, inexplicably the sea, withdrew from the area before 80 million years ago. The billions of shells of sea animals such as oysters, corals, mollusks, calms and brachiopods formed the sedimentary limestone rocks in the area, which are the basic raw materials for the giant cement plant in the region.

These limestone deposits and fossils embedded in successive layers of rocks were to paleontologists like the printed pages of nature's own book of the history of the earth. While the fleshly parts of the buried marine creatures, rotted away quickly, the hard part such as the bones and shells has remained for years without suffering much damage, the pores and empty spaces are partially or totally impregnated with mineral deposits from the seeping sea water and in course of time, these structures has got hardened to form fossils. Hence the land is termed "Land of fossils" and as the "Holy place for Geologists".

Ariyalur covers 2 lakhs hectares of Tamilnadu; the population of Ariyalur is 8 lakhs. In summer the temperature ranges between 30^{o}C to 38^{o}C. During winter day the temperature ranges between 22^{o}C to 27^{o}C. Rain fall per year is about 867 mm.

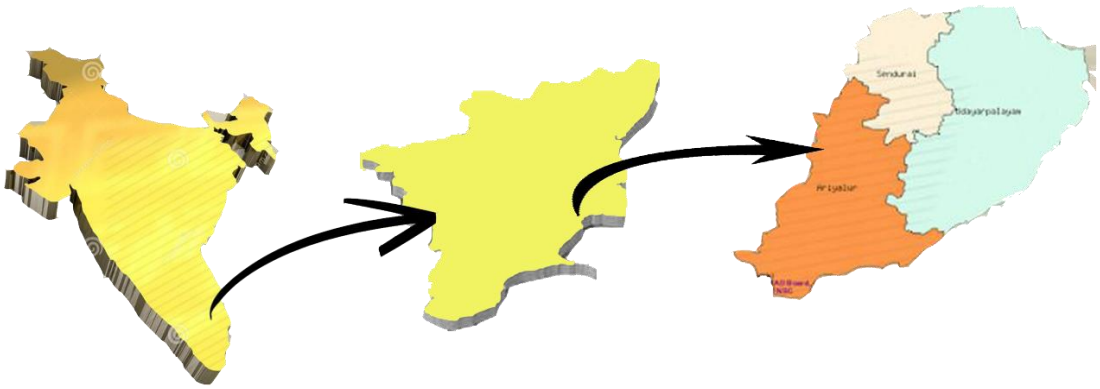

FIG.1. STUDY AREA (www.ariyalur.com).

TRADITIONAL HOUSES OF ARIYALUR

The earlier part of this series highlighted the traditional homes of northern India. In this section, we shall delve into the homes of southern India and take a look at the old traditional homes that have always been the landmarks of a joint family system, a concept that has been and in many ways is still an integral part of Indian culture.

The state of Tamil Nadu covers a large area, as well as, finds itself home to different geographies. On the eastern coast lies the Bay Bengal, whereas, on the west the Nilgiri Mountains tower. The land in between is often termed as semi – arid and hence the architecture of its traditional homes also vary in many nuances across the board. However, the basic structure does not alter much, though Tamil Nadu homes can be distinguished or classified further into sub parts. Also, the classification is not based alone on the regional variations, but also on class variations. A rich, prosperous traditional home looks different from that of a poor man. Where the poor used mud and rice husk the rich used sundried and mud bricks.

However the lime plaster on the walls to reflect the sunlight remains the constant material in the building of the homes. Some other features in Tamil Nadu traditional homes that are same almost everywhere is courtyard in the interior of the house, as well as the raised

verandah called the Thinnai in the front or at times all around the house, used for social functions as well as family gatherings.

COURTYARD FORMS AND ELEMENTS

The basic courtyard form of dwelling is rectangular or cubic, round or curvilinear but it's not fixed. The courtyard form have been particularly modified to adapt to the building orientation, site restrictions, topography and also to create formal shapes to increase the adaptability and flexibility in planning, such as the L, U, H, T, V or Y.

Sullivan observes that "The size and scale of a courtyard can vary from intimate to quite spacious. In each and every case, the courtyard creates a wonderful frame of light and air (Sullivan and Chip, 2002). Based on the literature study, most of the courtyard houses worldwide are restricted to 1-5 floors. The maintaining of the proportion and scale of the building is important to allow the courtyard with ample lighting and ventilation.

Classical Indian architects called a vernacular architectural term ―*Veedu*, on the houses in Kerala, that the architectural system of the joint family houses. So, it is considered ―*a very common vernacular term for house among the tribal communities*. *Veedu* is an Asian term that was used in some places of northern Srilanka for the major kind of residential architecture.(Susilo, 2016). Those architects appreciate the concentric layout of settlements specifically of the *Sala* or hall. Regarding that, there are some houses which called ―*Catusala*, to be so associated to the local Indian architectural term *Nalukettu*, a four-hall settlement/courtyard settlement. The houses of Muslims and Christian Syrian in Kerala is simply considered the most houses which were structured regarding this indigenous-vernacular architectural style *Veedu* /*Catusala* with a central courtyard.(Susilo, 2016).

The influences of community interactions in India are clearly appeared on features of their traditional architectural dwellings or

settlements such as terraces, pavilions, threshold and courtyards (Gupta, 2016). Article will be highlighted on the former feature which is considered one of important and common pattern in Indian traditional architectural heritage settlements. Regarding the history of Indian built vernacular heritage, the architectural component ―Courtyard is considered so significant that it might play a role of sacrificial altar or a place for family marriage. Through the last sentence, we can assert that Indian architectural formation met with the needs and wants of the traditional family system. Myneni mentioned in his article that ―*the total number of courtyards in one residence could sometimes be five to six.* (Myneni, 2013).

Indian archaeologists discovered a mud brick-constructed settlement which dates back to around 6000 B.C (Myneni, 2013). Those archaeologists found the rooms of this dwelling surrounding a central courtyard. From my point of view, this feature is coming back to the effect of social aspect that the major of mud brick-constructed houses in Egypt have this central courtyard - which Egyptians called it by vulnerable language ―*Wist el-Dar,* the center of the house – that to smooth down the hot weather as well as all member of Egyptian family gather in. In the settlements of Ariyalur, we can observe, regarding the cultural requirements of the community, the different function for the courtyard that the family members collect regularly through the water of rains, as well as small courtyards as an interaction space in order to act the household activities (Myneni, 2013).

ANALYSIS AND INFERENCE

In the traditional house, the activities are connected towards the courtyard due to the central position of the courtyard, as it is the central breathing space of the house and becomes center of life within. Since there is no rigidity in planning, the courtyard can be called as the space that generates a lot of activities. When any outcome that’s evolving over a point of a period, a very much sensible adoption and way too careful

amalgamation of the form that evolved in to the planning of residential building is done, it will definitely contribute more sense to architecture, which clearly justifies why vernacular architecture is still an example to learn from the past for the present and the future. In the typical traditional house, the courtyard will be the primary element of the house as it is in the center and all the other rooms were built around the central courtyard and the connection between the inside and outside of the house provided by this space, functioning as both the light well and ventilation shaft. The courtyard is the element that is moving vertically from ground floor to roof and it should be open to sky to fulfill its basic requirements (Susan ubbelohde and George Loisos, 2000).

The main goal for providing courtyard is to provide an escape point for the heat gained by the house during the day time and to create a stack effect, as the hot air always tends to move upwards. And to make sure that the inside and outside of the house can be clearly defined in the hotter months. The house with courtyard functions as a protective shell by keeping the outside heat at some distance and providing a micro climate for the house with proper shading and cooler surfaces, which will be basic requirements of the occupants as a response to the daily temperatures due to the solar radiation (Susan ubbelohde and George Loisos, 2000). Though the thermal capacity of the materials used in the building will hold the primary key to achieve the thermal comfort of the building, by adding the courtyard as one of the design element, which will only improve the thermal comfort of the building (Vivek Nanda, 1989). During the summer season the capacity of the building to reradiate the heat gained during the day to the night sky will definitely not equal to the daily radiations that the building received (Vivek Nanda, 1989). Due to this the required thermal comfort will not be achieved. So, by adding courtyard, efficiency for achieving this will be increased. The courtyard is often the place for washing clothes, dishes etc., and also the residents of the old house washing the courtyard few times a day to keep the dust away. Thus the pattern for providing evaporative cooling within the house will counteracts the heat gain increasing from the solar radiation over the

summer months (Vivek Nanda, 1989).

Since the thermal capacity of the carved wooden pillar facings in the corridor around the courtyard is low that will reduce the incident solar radiation up to an extent (Jain, 1988). Although the horizontal openings create more heat gain in the building by heating up the larger open interior mass throughout the summer season, but it have been kept from too much heating by the daily house hold activities. The house is flushed with cool air during the night time and the hot air will be sucked away through the stack effect. Courtyards function can be both ways. It can act as an air funnel by the stack effect concept and it can also act as suction zone sucking the air from the open to sky (Mihir Vakharia, 2014).

The courtyard will improve the thermal conditions of its surrounding spaces at night time, if provided sufficient openings on those spaces. The rooms facing the courtyards should have double sided ventilations; otherwise the speed of the air will be reduced. Larger window opening towards the main courtyard will improve the cross ventilation. Occupants in the courtyard houses will feel comfortable due to the regular intervals air exchanges. But in the house itself the effect of the courtyard is more on the ground floor only since the rooms surrounded by the courtyard are nearer to it than to the first floor (Mihir Vakharia, 2014). This is due to the direct solar radiation on the roof surface.

Research shows that the rooms in the ground floor than the first floor adjacent to the courtyard can actually efficient enough to maintain lesser temperature than the outdoor temperature (Mihir Vakharia, 2014). The courtyards can be used for passive cooling, to improve the IAQ and natural lighting. Thus, courtyards have been playing a role of major built component since the past in creating better lighting, ventilation and thermal comfort. It also acts as a space to gather, a space to interact and a space with lot of activities. Creating better living solutions with the way of adapting and learning the lesson from the past, to create the sustainable solutions is the need of the hour.

THERMAL PERFORMANCE ANALYSIS IN TRADITIONAL HOUSES

- For the entire month of May, the indoor spaces of the house maintain a stable temperature, ranging between 32.1^{0}C to 36.7^{0}C irrespective of the temperature variation outside, ranging between 26.7^{0}C to 41.3^{0}C.
- The maximum temperature of the indoor spaces for the critical month of summer (1st May to 31st May 2020) is as follows:
- 35.9^{0}C for living space, i.e., 5.4^{0}C lower than the maximum outdoor temperature, 36.7^0 C for front room on the western side, i.e.,4.6^0 C lower than the maximum outdoor temperature, 36.6^{0}C for front room on the eastern side, i.e.,4.7^0 C lower than the maximum outdoor temperature, and 36.1^{0}C for side rooms on the eastern side, i.e.,5.2^{0}C lower than the maximum outdoor temperature.
- The living space around the central courtyard and the private rooms on the eastern side maintains slightly a warm temperature ranging between 32^{0}C to 36.1^{0}C throughout the month with a diurnal variation of 3.9^{0}C and 2.9^{0}C respectively which shows a considerable difference from the outdoor temperature.
- The minimum temperature of the indoor spaces for the critical month of summer period (1st May to 31st May 2019) is as follows: 32^{0}C for living space, i.e.,5.3^{0}C higher than the minimum outdoor temperature, 32.1^{0}C for front room on the western side, i.e.,5.4^{0}C higher than the minimum outdoor temperature, 32.8^{0}C for front room on the eastern side, i.e.,6.1^{0}C higher than the minimum outdoor temperature, and 33.2^{0}C for side rooms on the eastern side, i.e.,6.5^{0}C higher than the minimum outdoor temperature.

CONCLUSION

The study evidenced that the reason for significant temperature difference between inside and outside temperatures of the traditional building in summer is because of the evaporative cooling phenomena that takes place in lime mortar based masonry wall of the traditional houses of Ariyalur. Low thermal conductivity, less thickness of roofing and walls of

concrete based modern building depict the higher mean radiant temperatures and higher temperature variations of modern building compared to traditional building. On the other hand, the modern residential buildings lack the above aspects and are therefore uncomfortable to stay in summer. The position of courtyard or any open space decides the users and its pattern of use. There are no other derivatives of the courtyard that can replace the feel and porosity like that form itself can give although it satisfies some of the functional requirements of courtyard like may be lighting. Major alterations to the courtyard can completely give a different sense of space and utility, not the one that can be achieved from proper courtyard form. By doing that change it will only give more sense of a room rather the feel of an open space. Courtyard is the *"key element"* that has established its vital role of importance in the society and in the field of architecture according to time.

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