Environmental effect of courtyard in sustainable architecture of Iran (Cold regions)  
(Case study: courtyard houses in Tabriz)

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ABSTRACT

This paper concentrates on the results of sustainability caused by Courtyard as a climatic element in Iranian traditional architecture of cold regions. Traditional architecture of Iran is perceived sustainable for having sustainable features. It is able to respond to environmental problems from a long period. Its features are based on climatic factors as well as local construction materials of cold regions and Courtyard (hayate- markazi) is one of these features. Courtyard as one of the determining and organizing factor of traditional architecture in cold regions involves various aspects. This research uses library documents and Internet sites as well as analyzing building plans. Result of this paper; show that considering the experience in traditional architecture of cold regions, it is possible to create an environmental and sustainable architecture.

Keywords: Sustainable Development, Sustainable Architecture, Cold regions, Courtyard, Environmental Architecture, Green Architecture, Typology.

1. INTRODUCTION

Sustainability in architecture means conserving constructions for the future, in terms of physical durability planet protect conserving on energy resources. In this case, it seems that sustainability would be based on the introduction productive models in which available materials and resources are used more efficiently, rather than being ignored. Nowadays, the knowledge of building ecology focuses on its capacity to integrate environmental and climatic parameters into design and thus enhances space qualities such as comfort ability. Traditional architecture of Iran is perceived sustainable for having sustainable features. It is able to response to environmental problems from a long period. Its features are based on climatic factors as well as local construction Materials of cold regions and Courtyard is one of these features. Courtyard as one of the determining and organizing factor of traditional architecture in cold regions involves various aspects. Knowing different features(material,window,symmetry, orientation and etc) in environmental design of Iranian houses, along with examining and comparing case studies in some Iranian cities like Tabriz,… could determine various aspects of environmental and climatically factors in Iranian traditional architecture and provide approaches for contemporary architecture.

2. CLIMATE OF IRAN

2.1 Classification of climate in Iran:
“Climate is integration in time of the physical state of the atmospheric environmental characteristic of a certain geographical location. There are different geographical locations in Iran and this provides various climates and every climate has its special characteristics. Iranian researchers, like M. Tavasoli, M. Kasmaee, Dr.H.Ganjee worked on climatic divisions of Iran but the method of Dr.H.ganjee is the best. He divided Iran based on Koppen’s method. Koppen divided the world based on growing of plants. Microclimates have effect ed on urban planning and architecture. In a vast country such as Iran, with different climatic zones, traditional builders in the past have presented a series of logical solutions for human comfort. Iran is basically divided into four climatic regions: Mild-Humid Climate-Cold, Climate-Hot-Mild Climate-Hot-Arid Climate.”

3. THE ROLE OF COURTYARD IN SUSTAINABILITY OF TRADITIONAL IRANIAN HOUSES:

The courtyard in a cold climate is usually the heart of the dwelling spatially, socially, and environmentally. Although, the size of the land, to some extent, is influential, the average sizes of the courtyards are generally determined according to the latitude. They are narrow enough to maintain a shaded area during the heat of the day in summer, but wide enough to receive solar radiation in winter. A courtyard can provide security, privacy, and a comfortable place within the house. The courtyard where it is usually planted with trees, flowers and shrubs, not only provides comfortable condition and beautiful setting. In Tabriz and some other cities of the western part of Iran, the cold weather and snow. On the side opposite the open archway where often are rooms with
the greater exposure to sunshine in winter. While larger houses have rooms all around the courtyard, smaller ones may have rooms only on three, or two sides of the courtyard shallow pool is often found in the courtyard which may provide more humidity, and warming physiologically and psychologically. The floor of the courtyard is usually tiled with baked square bricks (farshi). “Even without modern, mechanical heating or cooling systems, the courtyard house provides a comfortable living environment through seasonal usage of sections of the structure. The thermal performance of courtyards have been studied by many researchers. (Roaf 1982, Bonine 1980, Givoni 1976, Dunhamm 1960).

4. ENVIRONMENTAL ANALYSES OF COURT-YARD IN THE IRANIAN TRADITIONAL HOUSES

The courtyard in a cold climate is usually the heart of the dwelling spatially, socially, and environmentally. The courtyard in a cold climate is usually the heart of the deliberation of specialty of socially, environmentally are architecture. In this article studies are based on different typological imagination of various kinds of traditional Iranian houses are comparatively spread in vast cold climate in this country with aim of comparison the environmental specialties of courtyard architecture from climate aspects. In these studies two aspects physically flesh subsistence biological is analyzed. The base of this article is on analysis and studies of documents like plans, sections, and facades are the examples of Iranian architecture in Traditional texture, In cities like Tabriz, Ardebil,… , this towns are in cold climate. But in every named cities, Minimum three valuable buildings are selected and biological body analyses has been searched on them that the final result will be introduced in this article.

5. PHYSICAL – ENVIRONMENTAL CRITERIA FOR COURTYARD ANALYSIS

This research lays the foundation of a detailed study as morphologically analyzing the physically formal products of a courtyard which is located in a vast site between different climates in cold area. This in turn, provides a stratum that allows us to measure explicit and implicit characteristics of an architecture having anything to run with climatic aspects. Given the roles, as already explained, that a courtyard plays in developing and regulating the structures particularly housing architecture and as we need to achieve formal models of it, it is necessary to analyze a courtyard among these climates. For that reason, it will be explained in a comprehensive way in this study. It is evident that observing the physical – Environmental criteria for courtyard and analyzing studying models and introducing and employing these details in designing a courtyard as a private open space in our contemporary architecture can lead to a produced sustainable architecture in the said zones.

5.1 criterion 1: the symmetry between an solid space (occupied space) and a void space (unoccupied court yard)

One of the architectural principles in Iran is how to use a module in the sense of following geometrical science and its discipline. This is largely utilized in the Iranian architecture the same as used in western architecture because they both relatively follow the same module. Module, in the past, was used as an equally micro– measurement device that had to be incorporated at any place proportionate to it. The part architect works (monuments) of Iran in particular in Islamic periods indicate that how much deeply and extensively geometry was employed in different styles of architecture. In past Iranian architecture, any typical linking between various elements was developed on the basis of a negative spatial geometry (courtyard). The geometrical dimensions of this space took up forms from special geometrical morphologies (shapes) such as square and oblong which as a matter of fact are not free from limitations and disadvantages as far as their performances are concerned because it accommodates a definite number of architectural elements. But, having available geometry for a courtyard allows us to have a free hand to develop good forms of facades and how to divide a building in its entirety. This parts of study deals with the ways in which we can consider the area of an occupied their proportions to the total floor area of a house.

5.2 criterion 2: The Extension direction and rotation angle of a courtyard

Some rotations of this type can be re – known from the positions they take and how much they are available. However, it would be a wall that is entirely parallel to streets. The main reasons for it that can be referred to here are those of (1) climatic orientation, (2) a right angled sequence or quadrilateral is followed by its form as well as (3) the positions of streets and their access roads or paths. As regards older cities with no network pattern for courtyards, the orientations of courtyards are posed based on the observation of equitable diffusion of the light of day on the bodies. Sunlight radiates onto the courtyard to give benefits to humans and plants but what side at a courtyard receives the direct sunlight and what time of a day, where and in what locations the light of day is at its minimum or otherwise are all considered to be optimum comfortable conditions a temperature can provide. The ground lowering or sinking on a level below the surface of the ground a lane has, high
walls of an outside fence and the orientation of a house to sunlight which is synonymous to a juxtaposition of a courtyard’s dimensions as focused on the north and south or the orientation of one courtyard’s side to the direction of kaaba can create a structure that provides the most amount of shade during scorching days in summer and the most penetrating light and heat of sun deep into the rooms in winter. Each front side of a courtyard with sun orientation is special to a definite season but the sequence of room in the living room and wind catcher, three – door rooms, five – door rooms and other special spaces used during four seasons of year. Also, one can identify and determine the history of their development during different historical progression by considering and looking into different orientations of yards in a city or in a living complex. Over time, the orientations of courtyards have developed into their optimum positions and remained stabilized in their present positions. As for courtyards with their oblong form and shape and their eastern to western extension, the higher facades are situated in northern and southern fronts. This typical orientation prevents the sunlight from radiating directly on higher façade. Arches of lesser deep make the openers ready let to blow through them. The shorter front, in turn, the sun’s strong and direct these facades are deprived of daylight in winter. Totally choosing the side in the house is related to direction of street and availability to them. Although the relations are related to analyses of availability but from the main reasons is about climate aspect and from dependence of a right side rectangular and the situation of streets and availability to them. The sun will influence the court yard, the plants and human could use the warmness and light of it. The sides which will accept sprightly influence of sunlight and the best time that court yard has maximum or minimum acception of sunlight. So the best time of facilities would be clear.

5.3 criterion 3: proportions associated to courtyard dimensions
Some ratios (proportions) have been calculated to obtain the physically formal characteristics of selected patterns across the horizon for understanding length – width ratio and along an upright for obtaining height – length ratio and that of height to width.

5.4 criterion 4: The proportions of physical bodies of courtyard
Courtyard, as an organism and ecosystem is made up of bodies. These bodies can be separated from each other in two major categories. The first category is natural bodies that consist of soil (other minerals), sky, water, plants and human. The second category consists of man – made bodies such as frame, architectural material and human products which a butt each other. This paper substantially shed light on the physical bodies of earth and water that influence considerably the analysis of bio-environment of courtyard.

5.4.1 earth
Earth a vantage ground for every architecture in houses of cold climate, has been able in such a way to arrange for a space for it exactly both under and above it self so that it may be able to take advantage of fixed temperature assed and that of fixed humidity which both culminate in a heat–humidity exchange rate supported by environment and their surrounding bodies and finally lead to air current. This section also deals with the surface of earth on courtyard. It will likewise consider the proportions of soil surface to the entire surface of courtyard in studying models.

5.4.2 Water
Water is a variable that plays and enormous role not only in the space of courtyard but also within the surrounding Limits of a city. It also constitutes a basis on which a city is truly urbanized and houses within it are acclimated in land where water is valued as a rave gem. The levels and bodies of water that are observed as stagnant and dynamically flowing in courtyards results in a condition under which humidity can be spread up in space. Water plant, sun and wind are each employed through traditional technology and provide a harmonious set of environment efficiencies water, in two latent and vivid alternatives plays the most important part in developing traditional texture. Therefore, this section discusses the proportions and levels of water and earth as the physical and natural bodies of courtyard in model studies.

5.5 criterions 5: symmetries of artificial bodies (quadruple elevations of courtyard
This study examines into the dimensions and sizes of four northern, southern, eastern and western elevations of courtyard in case studies. Also, in this way the proportions related to the levels of four fronts to that of courtyard will be calculated and included in table.

5.6 criterions 6: the symmetries of openers in artificial bodies (opener in the four elevations)
This section also studies the dimensions and sizes of four northern, southern, eastern and western elevations. Also in this way the proportions related to the ration of opener’s levels in the four fronts to that of total four fronts in case studies.
5. THE RESULTS OBTAINED FROM THE PHYSICAL-ENVIRONMENTAL ANALYSIS OF COURT-YARD IN HOUSES WITH VERNACULAR COURT-YARD IN COLD CLIMATES:

This section deduces the case examples as obtained from environment analysis. It also selects model cities from each intermediate climate considering factors such as the oldness of structure, historical value, renovation value, specified plans and etc. then, three houses with courtyards were also for model studies. Finally it analyzes the courtyards of selected houses based on formal criteria as concern their proportions as introduced and elucidated in previous section. To reach its final conclusion, that is to say, to achieve the same proposed model of correct proportions for designing a courtyard, the paper primarily draws and analyses all plans by using Auto-Coding software. Then, it formulates all deduced results and outcomes in tables with the aide of Excel software and ultimately it presents a proposed model for creating correct proportions to design a courtyard (as suitably used for each city) and a concerned middle climate. This paper selects from cold climate one city such as Tabriz as models and also selects out of which four houses with courtyards. In this way, it selects from the city of Tabriz thee houses belonging each to Salmasi, Hariri, Mirzaei and Mashrooteh as models for studies and analyses based on formal- environmental criteria as concern the proportions. It finally presents, some proposed formal models to suit the proportion of courtyard in a climate.

6. THE RESULTS OF FORMAL ENVIRONMENT ANALYSIS OF HOUSES WITH VERNACULAR COURT-YARD IN THE CITY OF TABRIZ:

Result obtained from the analysis of six formal criteria related to proportions in model studies on houses belonging to Salmasi, Hariri, Mirzaei and Mashrooteh are:

6.1 criterion 1: the symmetry between a solid space (occupied space) and a void space (unoccupied courtyard):
In the models that were studied it was found that on an average the area of house on northern part is about 114 m² and that of southern part about 66 m² and that of eastern part 112m² and that western part about 106m². The ratio of clearly unpopulated space (courtyard) to the whole surface area is about 47% and that of occupied (living) space to the whole surface area is 53%.

6.2 criterion 2: the extension direction and rotation angle of a courtyard:
All models display that the extension direction of northern to southern is with a mean proportion of 1/2 and no rotation to the axis of north southern.

6.3 criterion 3: proportions associated to courtyard dimensions:
In models that have been studied if was found that, the surface area of courtyard is about 430 m² and its proportion about 1/2 and the form of courtyard is oblong and there is and analogy longitudinal latitudinal.

6.4 criterion 4: proportions for natural bodies of courtyard such as water and earth:
In models studied, it was learned that the surface area of water is about 15.5 m² and its proportion to the surface of courtyard about 1% and the earth area about 104 m² and its proportion to the surface of courtyard about 11%.

6.5 criterions 5: symmetries of artificial bodies (quadruple Elevations of courtyard):
In models that have been studied, it was learned that the area of northern front is 114 m² and that of southern front 66 m² and that of eastern front 112 m² and western front 106 m². The ratio of northern front surface to that of courtyard are about 13% and the surface of southern front to that of courtyard about 7%, the surface of eastern front to that of courtyard about 12% and western fronts to that of courtyard is about 11%. It is observed that the widest front surface concerns that of northern and the narrowest of it concerns that of southern.

6.6 criterions 6: the symmetries of openers in artificial bodies (opener in the four elevations):
In models that have been studied, it was found that the areas of openers in northern fronts are 50 m² and those of southern about 5 m² and those of eastern 12m² and western 6 m². Also the ratio of northern front openers to courtyard is about 43% and that of southern about 7%, that of eastern 10% and western about 5%. It is observed that the widest surface of openers concern the northern front and the narrowest of it concern the southern and western fronts.

7. CONCLUSION:

Finally, then Tabriz city and four houses with courtyards from each were chosen from amongst climates and were analyzed with physical – environmental criteria related to proportions. The following results were obtained from the analysis of six formal criteria concerning the proportions to four studied:
• The ratio of clearly unpopulated space (courtyard) to
the whole surface area, Cold climate of Tabriz is about 47% and that of occupied (living) space to the whole surface area is 53%.

• All models in cold Climate of Tabriz display that the extension direction of northern to southern.
• The proportion of courtyard in cold climate of Tabriz is about 1/2 and the form of courtyard is rectangular.
• In Cold Climate of Tabriz, proportion of water area to the surface of courtyard about 1% and proportion of earth area to the surface of courtyard about 11%.
• In Cold Climate of Tabriz, the widest front surface concerns that of northern elevation and the narrowest of it concerns that of southern elevation.
• The widest surface of openers Cold Climate of Tabriz, concern the northern front and the narrowest of it concern the southern and western fronts.

In Final word: the role a courtyard plays as factor to provide micro – climate must be taken into consideration because it is exceeding effective to regulate and develop building especially housing structures.

REFERENCES


NOTS
This article is a part of writer’s Ph.D thesis: Soflaee,Farzaneh, 2006, “Environmental Analyzes of Courtyard in the Sustainable Architecture of Hot-Aired Region”, Islamic Azad university, Research & scientist Branch, Tehran, Iran.