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The Effect of Balcony to Enhance Natural Ventilation in Local Houses in Mazandaran Province

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Abstract

Utilization of natural ventilation in buildings has a long history. Architecture has been trying to response to weather conditions all the time. Wind catcher, mashrabiya, portico and iwan are some examples of climate designs in vernacular architecture which have shown the importance of natural ventilation since a long time ago. The efficiency scope of natural ventilation when used with other cooling techniques will be more widespread. Today, designing desirable buildings using natural ventilation requires knowing theoretical foundations and a detailed study based on new knowledge regarding the feasibility of the use of components design and equipment related to natural ventilation. The present research aims to offer architects some design solutions in order to take advantage of natural ventilation in buildings using the vernacular architecture. Through matching features of functional spaces in local houses with climatic characteristics of regions around the Caspian sea (Mazandaran province) and determining the pattern used in these spaces in housing areas, the present study seeks to answer this question: “Are types of local houses in regions with moderate and humid climate in Iran (Mazandaran) consistent with regional climate in terms of patterns applied in internal functional spaces? How do regional climate features affect physical form of houses?”

The results show that there is a direct and consistent relationship between vernacular architectural features of Mazandaran province and climate classification and regional climate. It also enhances home comfort in summer and finally, it can be concluded that local houses are built based on the climate classification and environment context, and natural ventilation is the most important factor affecting the conditions which improve environmental comfort. The present research provides some guidelines for the architectural design of residential buildings in regions with moderate and humid climate with the aim of achieving maximum level of natural ventilation. Also, in order to exploit the potential of natural ventilation, the results of the research will help architect select optimal designing parameters in harmony with the regional climate.

Keywords: Natural ventilation, Vernacular architecture, Comfort condition.

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Introduction

Formation of vernacular architectural elements is strongly influenced by environmental factors and the miracle of vernacular architecture in using regional materials and creating special techniques of construction as the best methods for meeting physical and spiritual needs of human being in terms of construction is obvious for everyone. Investigating local buildings is a short step to recognize indigenous techniques and knowledge of their creators when traditional tools and materials could provide only limited options for human. Today, the need for mechanical heating and cooling is minimized in buildings designed and built based on climate methods. In these buildings, in addition to exterior features, building plan is determined based on the use of climatic factors in terms of performance in different seasons. Therefore, the use of fossil energy is minimized and building energy is provided through renewable energy and comfort condition is achieved at higher level[4]. In the past, semi-open spaces in general and iwan in particular were considered as important spaces in traditional houses. Today's houses are built similarly in different climate and microclimate which this category leads to various problems caused by the indiscriminate use of fossil fuels. Mild and humid climate is observed in the southern coast of the Caspian Sea in Mazandaran. Paying attention to climatic factors as well as vernacular architecture in these regions can lead to patterns which not only save energy consumption but also provide a higher level of comfort. The present research seeks to answer this question: "can iwan as a main element in Persian architecture with some certain physical features enhance natural ventilation in buildings especially located in the Caspian coastal strip?" Therefore, the aim of this study is to evaluate the various types of ventilation patterns in indigenous housing in Mazandaran. This is a qualitative research and data is collected and analyzed through grounded theory.

Data is collected through case study. Case study provides an opportunity to gather precise and detailed information about the subject. In-depth and exact investigation, focusing on real events in real life content in limited time and space and a holistic attitude are all features of the present study. This kind of study is appropriate for making and testing theory[5]; therefore, it can be very efficient. Observing and reviewing documents are two main methods of collecting data in this study.

[4] Watson, et al. (1994), *Climatic Design, Administrative and Theoretical Principles of Use of Energy in Building*, Translated by Ghobadian, V., Tehran: Tehran University Press, p. 4.

[5] Javadin, et al. (2011), *Grounded Theory and Atlas.ti*, Tehran: Institute of Business Studies & Research, p: 15.

Stages of the research

A. First stage includes findings about climate, cities, houses, patterns and measurement standards. The results of this stage are as follows:
    1. Stage leading to identification and selection of cities.
    2. Stage leading to choosing houses in towns and villages to be studied in the present research
    3. The total typology of houses and identification of dimensions, directions, proportions and physical features of houses
B. The second stage involves simultaneous analysis of research data. Image description of selected samples is shown.
C. The third stage involves results and conclusion which the findings of the study can be provided.

Related review of the literature

Related review of the literature is classified based on studies conducted in the field of A. residential natural ventilation and B. investigating and categorizes of balcony.

Results obtained from related literature

Iwan

Every house needs a semi-open space and this category shows iwan performance and importance in the Caspian area which despite enjoying high airflow, house can be protected against raining from time to time in this region. Iwan is a place used for relaxing, eating, sleeping, entertaining guests, drying cloths and dishes and more. Therefore, iwan is functionally similar to room. Due to this category that iwan is the most important element in indigenous houses of Mazandaran, it has an enormous impact on improving environmental comfort. Iwan refers to a seating place higher than surrounding area which is commonly built in the outer part of the residential buildings. Experts believe that the eastern part of Iran, especially Khorasan is the cradle of iwan and great iwans have remained from Parthian period in Iran. The most beautiful and wonderful iwans are observed in Persian-Islamic buildings and mosques and Iranian iwans are often long and have been built with interesting and various arcades. In Amid dictionary, iwan refers to open space in front of the room, saffe, and an open space in building with no windows and according to Dehkhoda, it refers to saffe, arch, a seating place higher than other areas with ceiling and doorway. According to professor Pirnia (R.I.P), saffe means an iwan and a hall which have been covered with arch. Iwan allows

individual to define and delimit space and it is also the transitional space between earth and time factors. According to metaphysical perspective, iwan can be considered as a soul of house which is placed between garden and courtyard as soul and room as body[6]. Iwan can be considered both formally and conceptually as a point of transition from the earth to the sky[7]. Iwan refers to a semi-open space that is mostly covered and is located in front of living spaces and connects the open space of courtyard with the close space of inside.

Iwan is a wide and rectangular space which is built in front of one of the sides of the building which involves most of openings. Iwan space is usually open from one or two sides. Iwan is deep enough to the extent that its interior walls do not receive sunlight[8]. According to metaphysical perspective, iwan can be considered as a soul of house which is placed between garden and courtyard as soul and room as body[9]. Iwan is a connecting place and it appears in two forms (walled on three sides and open on one side). From exterior to interior perspective, since iwan is located in a place higher than other spaces in the building, it is considered as introducing and front space of building which validity of interior facades of courtyard depends on iwan value. From interior to exterior perspective, iwan refers to a determined wide space which is enclosed and considered as the main part of the house opened to small garden (yard) which means paradise. It is a symbol of perfection with its quadrilateral form and center (pool and water) and a symbol of the universe which is static with no direction in the most perfect yard that is a yard with four iwans. Four iwans represent four sides of the universe which look at the center of the small world. Therefore, a complete Mandel (the universe mapping) is formed in the heart of the smallest unit of the traditional city (house)[10].

Iwan importance in architectural structure of the house

In the past, semi-open spaces in general and iwan in particular were considered as important spaces in traditional houses in Iran. These spaces influence overall organization of the building with two open and close spaces and are considered as independent areas which have a variety of functions. Iwan is considered as the most important one among them because it has its own architectural structure in physical, functional and structural terms. It should be

[6] Bakhtiar, et al. (2004), *Sense of Unity*, Tehran: Khak Publications, p: 23.

[7] Mahmoudi, A. *Investigating the Importance of Porch in Iranian Traditional House*, Tehran: Journal of Fine Arts, Tehran University Press, p: 25

[8] Aminian, et al. (2009), *Concepts and Definitions of Functional Elements and Spaces in Rural Housing of Persian Gulf*, Abadi Quarterly Journal, No. 6, p: 44.

[9] Bakhtiar, et al. (2004), *Sense of Unity*, Tehran: Khak Publications, p: 23.

[10] Mahmoudi, A. *Investigating the Importance of Porch in Iranian Traditional House*, Tehran: Journal of Fine Arts, Tehran University Press, p: 26.

said that Iranian architecture respects various biological aspects of human being and responses them appropriately. That's why even the category of transition which might be less considered in today's architecture involves significant physical and spatial values in traditional architecture and becomes a successful architectural pattern. Therefore, semi-open spaces are considered as transition points connecting open and closed spaces with each other and in this way, closed spaces are connected to open spaces through semi-open spaces. These spaces, especially iwan have common features of both indoor and outdoor spaces and have functional and physical performance. Three groups of open, closed and semi-open spaces are not constructed separately but each of them is meaningful along with others in architectural structure of traditional houses. In other words, spaces lose the degree of openness and closeness gradually in the way that they become connected to each other. This conjunction in the composition of spaces makes consecutive spaces be an extension of each other[11]. Moreover, iwan is extensively used in warm seasons and many functions take place there including eating, sleeping, working and etc. It also adjusts room temperature located in the back of it in all seasons and has a lot of values in climatic terms.[12] Since similar patterns of living have role in forming iwan in different parts of the country, this space enjoys a particular unity. Climate and natural environment and subcultures are factors which make a difference in the number, position and shape and decoration of iwans in different regions of the country which first two factors are more important.

Iwan in different ecological zones

Iwan has different and special shapes and forms in different parts of Iran. In the desert, it is vaulted and domed which is walled on three sides that connect to inside the building through a way. In the eccentric architecture of Gilan and Mazandaran, iwan is open on three sides and is placed outside the building. It has sloping roof on standing columns. In Abyaneh, a covered iwan which is open on three sides and located in the top floor is called Pachkem, pashkem, bashkem, bachkem. An iwan which is opened to miansara from one side is called saffe in Khorasan. Iwan which is settled behind the sun and used in summer is called hall in Yazd. A small iwan which can be seen in most of small houses is called hall in Masouleh. Iwan has flat cover in Tabriz which is walled on three sides. Iwas has been less used for sitting in cold weather; so that there is no space for sitting generally or the considered space for sitting is

[11] Haeri, M. *A Research on Practical Use of Architecture of Historical / Traditional Houses in Modern Housing Design*, Vol. 1 & 2, Tehran: Housing and Urban Development.

[12] Saremi, et al. *Sustainable Values in Persian Architecture*, Tehran: Cultural Heritage Organization, p: 109.

very small which was used in summer. Iwan was a place to prevent direct snowing on building facade and also it was a buffer space in front of the main spaces of the house to protect the house against cold weather. Table 1 summarizes the characteristics of iwan in different cities and indicates their local term.

Table 1. Iwan in different ecological zones, Reference: Nejadebrahimi

No.	City	Characteristics of Iwan	Local Term
1	**Yazd**	Vaulted and domed, walled on three sides	Iwan which is settled behind the sun is called hall.
2	**Gilan and Mazandaran**	Sloping roof with one end open.	-
3	**Masouleh**	Flat roof, open on three sides	A small iwan found in most of houses is called hall.
4	**Khorasan**	-	An iwan which is opened to miansara from one side is called saffe.
5	**Abyaneh**	Covered, open on three sides	Pachkem, pashkem, bashkem, bachkem
6	**Neyriz**	Flat roof, walled on three sides	-

Relationship between building and open space in houses

Usually, the composition and relationship of each building with open space are designed and constructed in the way that they become consistent with all phenomena affecting the formation and the way of using space, especially the phenomena related to natural and artificial environment in order to achieve the highest and best opportunity of using space. Study of traditional housing units in various cities and regions of the country shows that environmental phenomena have the most important role in the formation of building combination with open space because adjusting environmental conditions and building ventilation and lightening are of most important categories which have fundamental impact on the organization of the residential space. In general classification, types of housing units are

categorized into two groups of unidirectional and bidirectional spaces in terms of combination of building with open space.

Iwan and climatic design

Protrusion of iwans prevents the interior spaces and iwans body from receiving sunlight and keeps the surrounding cool through prevention of transferring heat. Generally, iwans and protrusions of the building keep it cool during the day and warm at night. Some believe that enjoying shadowed, open and fresh space in summer is the reason of having iwan in houses. The side walls accelerate and help better ventilation of the space. Since the vertical walls can drive air flow to the internal part of the iwan, the use of protruded walls in building facade leads summer winds into the building. Iwan built on the southern part of the courtyard catches the wind and if iwan is facing favorable winds, it can be widely used in warm seasons. Also, when there is no airflow, trapping cold air in the iwan back to the sun helps ventilation of the interior space.

Iwan in a region with mild and humid climate

Iwan and summer hall which are of the most important elements of housing units and the place for doing most of daily activities are considered as obvious layer surrounding the building and are constructed on foundations and positions higher than the ground to get rid of humidity of the ground. Floors are connected to the ground through one way stairs. Because of mentioned characteristics, residential architecture of these points is extrovert and outside space is more preferred to inside space most of the time. Connected iwans are an integral part in traditional houses because they have various functions such as living room, guestroom, bedroom, children's play room, a place for eating and cooking and whatever is necessary during day and night. Rooms are located behind the iwan which is mostly facing towards south. Unlike rooms of rural houses which have a single layer, rooms are connected to each other and have been made of two layers in many old houses in cities. Iwan is one of the important areas in house. This space has various functions and takes different forms according to the position of rooms. The simplest iwan has a protruded roof. Some beams and columns are used to keep beams used in the roof static. In this case, some columns are located in front of iwans from the simplest and smallest ones to the largest ones. In some buildings which have not elevated floor, horizontal beam separates iwan space from courtyard. In addition to this category that iwan is a place connecting outside space with inside space, it is considered as a place for sitting, sleeping and working in warm season. Another function of iwan is

connecting rooms with each other in multi-room houses. Therefore, according to the type of room, the position of iwans differs.

Investigating the role of iwan in houses located in areas with mild and humid climate

Because of locating vernacular contexts in pure space and their interaction with the environment, iwan is considered as a most important element in houses located in areas with mild and humid climate. Therefore, the role of iwan is very significant in local housing in Mazandaran in following cases:

Iwan and human interaction with its nature and sense of localization, iwan and its hierarchies, multi-purpose space of it, its fluidity and sustainable architecture are separately analyzed in the following part:

A. Human interaction with the environment: it is an interaction created between human and natural and human environment which forms a physical environment including physical context, architecture form, elements and architectural details. Houses located in areas with mild and humid climate have been inextricably associated with their own natural context. In this kind of architecture, iwan is indeed the symbol of true and respectful interaction between human and natural environment. This semi-open space plays a significant role in creating visual qualities and development of living process from closed to open space. It gives people this opportunity to enjoy beautiful scenes and visual perspective when doing their daily activities.
B. Through an appropriate orientation towards important directions and beautiful landscapes, iwan and its sense of localization make human being have a proper understanding and strong sense of the place concept.
C. Iwan and its hierarchy are considered as connecting space, a transition point between internal and external space, private and public area and closed and open environment. In addition to this category that iwan has a certain identity and personality, it connects open space (courtyard) with open or semi-closed space (iwan) and finally closed area (home) elaborately. In other words, public space of yard, then semi-private space of iwan and finally the private space of house are consecutively located in building.
D. Iwan and spatial fluidity: iwan creates spatial fluidity. Moving is a means of understanding space, and fluidity is moving in space by visual character and not by physical displacement. Iwan gives an opportunity which the possibility of watching

with no physical movement and displacement in space is provided. Spatial fluidity leads to comprehensibility of this kind of architecture and houses enjoy spatial dynamic, continuity and persistence. Spaces have fluidity and such fluidity has been provided through connective spaces such as iwan and it has created a certain attractive space in these simple dwellings.

E. Iwan as a multifunctional space: iwan is usually a carpeted place which its flexibility to cope with different functions makes it a multifunctional and multipurpose space. This place is very pleasant when it is used as place for sitting and collecting family members in the pleasant hours of a day. It is also used as a place for resting and night sleeping; therefore, it is called sleeping-porch in some areas. In some seasons, housewives use this space for doing their daily activities such as knitting during the day. Since iwan is a connecting space between closed space of home and open space of the yard, they can control and monitor both spaces appropriately. In some areas, iwan is used as a space for depot and temporary storage of products.

F. Iwan and sustainable architecture: iwan like other housing elements has pleasantly played its role as harmonious factors with climate. Through positive climatic performance and proper orientation towards the sun, iwans have provided optimal opportunities to make use of solar energy and natural ventilation. Proportions (depth and height) in iwan are in the way that absorption of solar energy becomes possible in winter and vice versa it prevents the absorption of light and heat in summer by shadowing the space. On the other hand, iwan which is a semi-open space between open space of yard and closed space of home minimizes energy dissipation caused by the opening and closing the entrance door and helps adjust environmental conditions. One of the distinctive features of Iranian architecture is using a connecting space between inside and outside. Iwans have been constructed because of climatic reasons. In the way that they have been designed consistent with the climate. Some changes have been observed in Iranian iwans by entering west-architecture in the middle of Qajar era into Persian architecture. In this way, iwan has lost its climatic function. Table 2 shows different features and functions of iwan based on physical, spatial, climate, and economical activities standards.

Table 2. Different features and functions of Iwan

No.	Different features and functions of Iwan
Physical and spatial	The space between inside and outside, flexibility and multi-functionality, a connecting space
Climatic	Air conditioning, keep the environment fresh and cool by shading, speed up air flow through the side walls, trapping cold air temperature when there is no air flow, dispersing the moisture accumulated around space walls, absorption of solar energy in winter and air conditioning in summer, reducing energy consumption at the entrance of the house
Economic activities of families	Depot and temporary storage of products, economic activities of women

Climate studies

Previous studies conducted on consistency between climate and architecture show that according to experts, architectural features in regions with mild and humid climate are formed to modify climatic conditions and depend on climate components. The purpose is to achieve an appropriate strategy consistent with climate factors of that place. These strategies virtually make architectural features of the place. Due to relative humidity and relatively high temperature, heat and rain effects, it is the most important objective to adjust the level of heat and humidity and rain effects in the area under investigation.

Strategies proposed

A. Use of the normal flow of air and prevailing winds
B. Local breeze and creating a shadowed space and prevention of receiving sunlight

Climate strategies are achieved through features and physical components of architecture in one place.

The sea breeze

In another part of studies conducted, the greatest level of the sea breeze penetration along the beach was investigated. The results have indicated that the maximum rate of flowing the sea wind towards land is in the afternoon 10 m/s and maximum depth of breeze penetration into land is 20 km and the most optimal and effective depth is 10 km.

Ventilation and the great effect of wind on ventilation

Studies conducted on the relationship between design and natural ventilation can be divided into three large, medium and micro scales. The purpose of designing natural ventilation in large scale is to investigate the effects of natural ventilation in relation to urban blocks with different heights, design urban open space, orientation of various dimensions and how the streets are connected to each other. The purpose of designing natural ventilation in medium scale is to investigate designing effective natural ventilation in relation to a building or a complex. Micro scale relates to investigating function of certain parts such as solar chimneys, atrium and wind catcher. The architectural design of buildings with natural ventilation includes research conducted on two areas of medium and micro scales. They have been extensively studied in the present research.

A. The medium scale which includes building shell, designing proportions, facade, openings, orientation, materials and thermal mass and ventilation patterns.
B. The micro scale includes ventilation components: the old ventilation elements such as central courtyard, atrium, wind catcher along with new elements such as side walls, ventilation ducts, double skin facades, and turbine ventilators are defined as ventilation components in climatic design. Balcony is the most important element in micro scale.

Climate classification and knowing microclimate

Various methods of climatology have been studied in research conducted on climatology. The present research is based on the Koppen-Trewartha method. Koppen-Trewartha classification includes six major climate groups. Five groups based on the five main heating areas and the six one which is dry group disconnects four heating groups except polar-climate group in another direction and it is defined based on the amount of rainfall. Therefore, temperature distinguishes five main climate branches and rainfall just one branch. Five groups with thermal criteria have a certain position in the world which is not applied in dry group.

The scope of the study

Mazandaran is one of the provinces of Iran. The Caspian Sea has been located in the northern part of Mazandaran. It connects to Tehran, Semnan and Qazvin from the south. It is limited to Gilan from the west and to Golestan from the east. Its southern part is mountainous and northern part is coastal plain. It covers an area of 24091/3 km² and 1/46 percent of the total area of the country is dedicated to this province.

Analysis of the cities and distance from the sea

According to previous studies, latest statistics reported in 2006 showed that Mazandaran has 16 counties, 44 districts, 51 cities and 113 villages. Since the sea breeze penetrates from the coast to the land in a distance of 10-20 km, it is required to investigate the distance between counties and the sea.

Climate classification of cities of Mazandaran

Since natural ventilation is one of the most important factors in creating environmental comfort and as wind and its speed and how deep it will penetrate into the land are important categories, penetration of the sea breeze which is effective on ventilation reported on a distance of 10 km from the sea after examining characteristics of the sea breeze and depth of its influence on the land. Therefore, cities were classified based on this category. Table 3 introduces stations and their distance from the sea and climate classification.

Table 3. Classifying stations based on climate and distance from the sea

No.	Station	Distance from the sea	koppen-Trewartha	No.	Station	Distance from the sea	koppen-Trewartha
1	Ramsar	10	Csa	**12**	Bi Kola research	20	Csa
2	Talarsar	10	Csa	**13**	Afrachal	20	Csa
3	Khoshkedaran	10	Csa	**14**	Tirtash	20	Csa

4	Khoramabad	10	Csa	**15**	Garm Rudabad	20	Csa
5	Nowshahr	10	Csa	**16**	Pol-e Zoghal	20	Csa
6	Rine Larijan	20	Dcb	**17**	Urimalek	20	Csa
7	Chamestan	10	Csa	**18**	Koresang	20	Csa
8	Babolsar	10	Csa	**19**	Soleiman Tange	20	Csa
9	Gharakhil Ghaemshahr	20	Csa	**20**	Erikanour	20	Dcb-Bwks
10	Faculty of Agriculture	20	Csa	**21**	Shirgah	20	Dcb-Bwks
11	Zardgol Sorkhabad	20	Dob	**22**	Mahmoud Abad Sari	20	Csa

Case studies (selecting cities and houses)

According to studies conducted on research methodology, sampling should be continued to the extent that the data collected suffice to prove theories and conclusion. If there is no possibility to present a theory or give an appropriate answer to the research question, sampling should be continued to reach data saturation. Of course, it depends on examples related to the topic under investigation. Also, the sampling method should be selective and based on the theoretical foundations of the research.

In this part, Mazandaran houses and their physical characteristics are investigated. Then the plan of 36 houses in Mazandaran are shown based on the climate classification presented and some features and standards such as proportions of iwan, window sizes, the distance between building and wall, the number of windows, the distance between windows and side walls, form of windows and window-to-wall ratio are analyzed. This study is conducted on houses which are at least 50 years old with common climate of csa.

Table 4. The baseline situation of houses

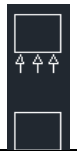
No.	City	Climate	Number of houses	No.	City	Climate	Number of houses
1	Amol	csa	4	**6**	Sari	csa	3
2	Babol	csa	4	**7**	Savadkouh	csa	4
3	Tonekabon	csa	3	**8**	Qhaem Shahr	csa	2
4	Chalus	csa	3	**9**	Neka	csa	3
5	Ramsar	csa	4	**10**	Nowshahr	csa	5

Based on the number of selected houses, first each house was drawn in AutoCAD and then they were statistically analyzed.

A summary of houses characteristics

In this part, a summary of houses characteristics is investigated with the criteria for the north direction, overall shape, extension of bio-space, open, closed and semi-closed space, communicative space and entrance direction. In table 5, 36 case studies are investigated and compared. This study includes some components such as name of city and village, north direction, general shape, biosphere extension, closed spaces, open and semi-open spaces, connecting areas and entrance position.

Table 5. Analysis of houses under investigation

No.	City	Village	North direction	General shape	Biosphere extension	Closed spaces	Open and semi-open spaces	Connecting spaces	Entrance
1	Neka	Chal mardi						Open in southwest direction	

2	Amol	Esku Mahalleh						Semi-open in south direction	
3	Savadkouh	Andar Koli						Semi-open in south direction	
4	Bobol	Pija Kola						Semi-open in south direction	
5	Sari	Pahne Kola						Semi-open in south direction	
6	Ghaem Shahr	Tir Kola						Semi-open in south direction	

Table 6 shows typology of iwan form and classification of houses in terms of number, percentage and common ratios and directions in this category.

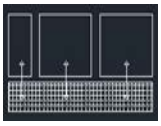
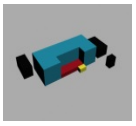
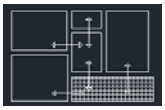
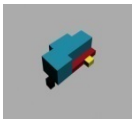
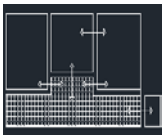
Table 6. Classifying houses based on iwan classification

No.	Iwan form	Number (house)	Percentage (house)	Common ratios	Common direction
1	Open on three sides and windows are perpendicular to the wind direction	4	11%	1:8 – 1:6 – 1:7	South
2	Iwan walled on three sides and windows are in wind direction and perpendicular to it	15	41%	1:6 – 1:3 – 1:2 – 1:4	South
3	Iwan walled on two sides and windows are in wind direction and perpendicular	9	26%	1:6 – 1:5 – 1:4 – 1:3	South

	to it				
4	Iwan walled on two sides and windows are in wind direction and perpendicular to it	8	22%	1:6 – 1:4	South

36 houses are categorized in six tables according to the city name, village name, living spaces, iwan position, three-dimensional structure of house, form classification, iwan modulation and connecting spaces. Table 7 shows the results of analysis of six houses investigated in the present study.

Table 7. An introduction to six houses based on typology of iwan

No.	**City**	**Village**	**Living spaces and iwan position**	**Three-dimensional structure of house**	**Form classification**	**Iwan modulation**	**Connecting spaces**
1	Neka	Chal mardi			Open on three sides and windows are perpendicular to the wind direction		Open in southwest direction
2	Amol	Esku Mahalleh			Iwan walled on two sides and windows are in wind direction and perpendicular to it		Semi-open in south direction
3	Savadkuh	Andar Koli			Iwan walled on two sides and windows are in wind direction and perpendicular to it		Semi-open in south direction

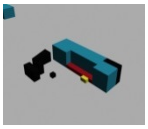
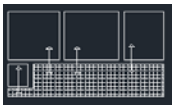
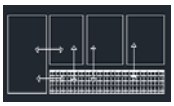
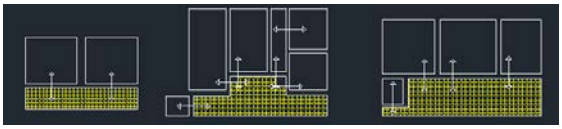
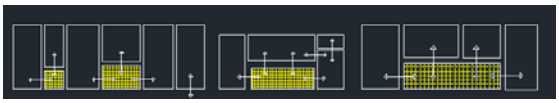
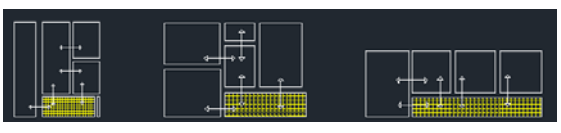
4	Bobol	Pija Kola			Iwan walled on three sides and windows are in wind direction and perpendicular to it		Semi-open in south direction
5	Sari	Pahne Kola			Iwan walled on two sides and windows are in wind direction and perpendicular to it		Semi-open in south direction
6	Ghaem Shahr	Tir Kola			Iwan walled on two sides and windows are in wind direction and perpendicular to it		Semi-open in south direction

Table 8 shows typology of iwan form and its common types. Table 9 introduces research statistical population which has been prepared for all houses.

Table 8. General form of iwan based on iwan classification

No.	Typology of iwan form	Common types
1	Iwan open on three sides and windows are perpendicular to the wind direction	
2	Iwan walled on three sides and windows are in wind direction and perpendicular to it	
3	Iwan walled on two sides and windows are in wind direction and perpendicular to it	

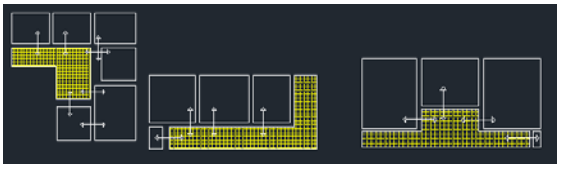
4	Iwan walled on combination of two and three sides and windows are in wind direction and perpendicular to it	

Table 9. Introducing houses

Architectural features of house			**Neka County**			**Chalmar di village**	**Owner: Gol Mohammad Shabani**					
Mazandaran province			Geographic longitude: 53119			Geographic latitude: 3639	Distance from the sea: 45					
group	Relation with the	percent	Total scale			Medium scale	Small scale					
			location	direction	form		ratios	window	Plan form	Access to	Main	Proportions in living
Closed space	close	84	Ground floor	East-West	Exterior, East-West direction, functional spaces at the same balance, direct relationship between rooms and outdoor, multiple wide openings	From yard to semi-open space From semi-open space to room	1:3	southern	rectangle	south	south	
Semi-closed space	-	10	-	-								
connective	open		Ground floor	East-West								
subsidiary	close	6	Ground floor	East-West								

Results

The certain design of buildings shell in Mazandaran is considered as an important element influencing ventilation efficiency. According to previous studies, there are some factors affecting natural ventilation in local houses; factors tested in the present study are of most importance.

Proportions

In various studies, some standards have been proposed about building proportions to achieve optimal ventilation. The results show that when the width of the building increases, maximum air speed will increase and better potential will be provided for natural ventilation. The optimal ratio between length and width of the local house in Mazandaran is 1:3 from north to south and the highest percentage of window area is towards the south and a very small percentage is towards the west and east. According to the results, it is necessary to set the house with prevailing wind direction and it is more preferred to use rectangular houses than other forms of houses. House designing are mostly done in one floor. Open plan designing in the interior space, closing the opening of eastern and western walls and building extension is observed in the east-west direction in houses. The category of building proportions is one of the factors effective on selecting patterns.

Facade design

Thermal behavior of facade components plays an important role in determining heat absorption in building and internal environment. Optimize ventilation for cooling a building can be created by reducing heat absorption. This category includes the way of using materials, thermal insulation of walls, colored glass and shadowing static components. In examining the potential of the natural ventilation in vernacular buildings of Mazandaran through medium scale and moderate climate, the role of openings and the location of building in distribution of indoor air velocity are studied. In addition to the proper orientation toward favorable wind, suitable interior design can increase ventilation capability in hot days. When the width of the building increases, maximum air speed will increase and better potential will be provided for natural ventilation. In this way, a rectangular building is proposed for houses located in regions with humid and moderate climate with ratio of 1:7, 1:4, 1:5 and 1:3; it seems to be an optimal choice for natural ventilation in moderate climate. Further studies are required by increasing the partition, the size of windows and inlet and outlet doors.

Building form

Enjoying wind will lead to comfort in building in regions with moderate and humid climate. In moderate and humid climate, the sultry condition is reduced by removing moisture from the environment. Building acts like a barrier against air flow and building form is effective on driving wind appropriately inside it. Building form should be in the way that air can be flown in the best way inside it. The building should be designed in the way that air is entered the building in funnel form; therefore, the input amount can be increased. When the building is rectangular and wind direction parallels to the longitudinal side, better ventilation will be done.

Plan and air flow direction

Frames, protrusions, shutters and other controlling elements of openings are effective on internal air flow. Protruded roofs are used in mentioned regions in order to prevent penetration of rain into the building and in this way driving air flow into the living environment will be more possible.

Air flow in plan

Factors such as designing protruded plan and creating beveled corners and angles against wind in order to increase the efficiency of wind energy, putting an opening in the place of entering air flow around the building just to drive wind into the building, use of protruded roof, partition and suitable furniture, proper position of the building which leads to driving air flow, and inserting an entrance space in a place of plan which has fallen back have great effect on ventilation by air flow.

Plan form

Local buildings can make use of semi-enclosed spaces to reduce humidity level in the summer; therefore, driving air flow in the surface and higher layers of the building will be easily possible. The level of humidity and rainfall is very high; therefore, residential building should be constructed in the way that it decreases the humidity level exceeding human tolerance. Hence, the humidity and temperature will be favorable. Wind flowing will be possible to remove humidity from the covered transparent layers with many openings in outer wall so that sometimes, a semi-enclosed space of iwans with no sides in addition to

establishing a relationship between housing units (rooms) has economical function and often is used as main space of living and in some cases as storage and servicing space.

Openings

Ventilation openings and windows are of main components in controlling the availability of daylight and ventilation. Ventilation efficiency can be improved by making changes in designing facade openings. In addition to openings' size, the location and orientation of windows define the distribution pattern of air flow in building. Type of window, size, opening location, and its angular feature are effective on making change in air velocity. The size of window is one of the most important elements affecting internal air velocity. When the wind direction parallels the opening direction, little air can enter into room. Wind velocity increases when its direction is oblique to the opening. Additionally, indoor air velocity does not always increase by increasing the level of window to wall. It depends on wind and building direction. In pattern selection based on the dominant percentage of window to the wall ratio, size, shape and location of window are investigated in buildings with the aim of achieving appropriate rate of air-conditioning and orientation and degree of building protection against wind in these rates. In the absence of a favorable wind, windows should be located in two sides of the building with different heights to create cross ventilation. Window is divided into two openings at different heights to improve one-way ventilation. When the window to the wall ratio increases, ventilation can be improved; however, heat absorption increases. This category determines the role of external awnings, especially for large windows. The overall distribution of opening size on the facade surface increases flexibility of different patterns of air flow and velocity. Better ventilation can be achieved through putting two groups of windows in opposite sides or perpendicular to each other. Based on previous studies, windows which are facing each other or are located in opposite sides and in north and south directions have the greatest impact on optimal ventilation.

Orientation

According to studies, orientation in different climates is determined based on radiation and heat received. In most of moderate and humid micro-climates, orientation is from north to south to make a balance between radiation and heat received.

Window direction

Window direction is important in terms of ensuring equal distribution of air flow in space. In most of cases, when there is an axis between entrance and exit, if the entrance direction is perpendicular to the prevailing wind direction, air flow will be directly driven towards the exit and will have little effect on other spaces. When windows are located on opposite walls and prevailing wind is blowing with an angle of 45 degrees towards openings, higher speed air flows occur within the space. Studies about quadrilateral buildings which are dominant structures in Mazandarn have shown that wind shadows exist. Exact positioning of openings and placement of internal walls can alleviate this category. In this case, air flow is internally directed and it is flown as far as the pressure difference at the outlet changes its direction. In situations with two-way ventilation, windows' size has substantial impact on air velocity. In order for air to flow into a building, it is required to get out of it; increasing the size of the openings, when the inlet and outlet increase at the same time has great impact. It should be noted that even when the windows are large, the wind speed is reduced. The average speed of air flow directly depends on the size of the smaller openings.

Position of window and its impact on natural ventilation

Studies showed that the best ventilation often occurs when the wind direction is oblique to the surface of the window. The favorite natural ventilation occurs when the air flow direction is changed inside the room rather than it gets out from the leeward window directly after entering the room from the window facing the wind. To use wind power in natural ventilation, the building must be built in a direction facing east or west. The best direction for placement of the building is incompatible in relation to wind blowing and sun shining. In areas where the favorable winds blow from the west or east, natural ventilation can be appropriately created inside the room through rotating the main facade of the building with the angle of 45 degrees toward south east or west direction.

Creating air flow in rooms with just one window

Shallow awnings can prevent receiving direct sunlight by southeast and southwest windows. If the favorable winds blow from northwest, northeast or southwest and southeast, north-south direction can be an appropriate position for building to create desired natural ventilation. It is very suitable in terms of controlling sun shining upon southern windows.

Internal separators

Position and orientation of internal separators can influence air flow and velocity inside a building. Generally, separators which are parallel to the air flow may contain minimal effect.

Balcony

Iwan is the most important element investigated in the present research. It affects natural ventilation. Balcony is one of the significant elements in building which forms external façade and volumetric composition of the building. Obviously, balcony as an architectural element, in addition to functional role and impact on external façade of the building affects thermal behavior of building and has environmental effects through shadowing the space. Therefore, if the function of air conditioning improves, balcony can reduce thermal load of the building along with shadowing, otherwise it will reduce the influence of shadowing. The present research shows that in addition to visual delight, balcony improves ventilation, provides an opportunity and space for planting flowers, and reduces the intensity of radiation received from the sun through acting as an awning. In this research, balcony is recognized as a transition space to create and control natural ventilation and internal and external conflicts in buildings. This research considers corridors and balconies as means for channeling wind and driving air flow to the required area. It is said that this part can be defined as a connector between external open space and internal closed space of the building. Balcony increases pressure distribution on the walls facing the wind; however, it does not cause significant changes in the leeward walls. Ventilation powers of openings are reduced in all floors regarding winds which blow with the oblique or perpendicular angle. Pressure distribution in the building increases from middle floors of the building to upper ones. Balcony can improve ventilation process in all rooms from first floor to upper ones in spaces with one-sided opening facing the wind; however, air conditioning is reduced in all rooms of first floor and central rooms located in ground floor and upper ones. In case of oblique wind, ventilation caused by wind power on openings surface facing the wind reaches to its highest level in top floor. Balconies in other floors reduce ventilation and increase it in central part of the top floor.

According to the results of this research, balcony alters the external air flow significantly; however, it reduces the efficiency of ventilation caused by the wind in building with one-way ventilation. If the wind blows with an angle of 90 degrees towards the building, balcony will decrease the efficiency of external wind to create natural ventilation in one-sided buildings. The combination of balcony and opening has also an important role in creating internal air

flow. Inappropriate combination of openings in balcony reduces mostly internal air flow. To optimize the internal flow, understanding changes in external air caused by balcony is required to make an optimal combination between opening and balcony. Internal air flow is significantly changed by changing altitude and block location. The present research recommends further studies to investigate the effect of balcony in various wind angles. According to the results, function of one-way ventilation can be improved through making use of facade components such as balcony in compared with flat building, although it is less desirable compared to two-way ventilation.

Conclusion

The results of the present study indicated that houses in cities and villages in Mazandaran province are located in an ultimate distance of 20 km from the sea. All vernacular buildings in climate plots emphasize on need for air conditioning. In most cities located in common microclimate, they can provide comfort condition in winter but it is not possible in days and nights of summer using climate pattern. The results show that although patterns of functional spaces cannot provide comfort condition in days and nights of summer in buildings under investigation, physical features of houses are key factors in providing such condition.

In this research, balcony is recognized as a transition space to create and control natural ventilation and internal and external conflicts in buildings. This research considers corridors and balconies as means for channeling wind and driving air flow to the required area. It is said that this part can be defined as a connector between external open space and internal closed space of the building. Balcony increases pressure distribution on the walls facing the wind; however, it does not cause significant changes in the leeward walls. Ventilation powers of openings are reduced in all floors regarding winds which blow with the oblique or perpendicular angle. Pressure distribution in the building increases from middle floors of the building to upper ones. Balcony can improve ventilation process in all rooms from first floor to upper ones in spaces with one-sided opening facing the wind; however, air conditioning is reduced in all rooms of second and third floors and central rooms located in ground floor and upper ones. In case of oblique wind, ventilation caused by wind power on openings surface facing the wind reaches to its highest level in top floor. Balconies in other floors reduce ventilation and increase it in central part of the top floor …

A. Climate patterns of functional spaces in vernacular houses are consistent with microclimate features.

B. Due to patterns of prevailing and local winds, air flow patterns operate as static systems of natural ventilation.
C. Comparison of values related to space proportions in buildings under investigation shows a significant relationship.
D. The most important factors in vernacular short-height buildings in Mazandaran are proportions and window and house orientation and proportions and form of iwan which affect ventilation efficiency.

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