

# Design Fundamentals in the Hot and Humid Climate of Iran: The Case of Khoramshahr

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Received: August 18, 2011

Accepted: October 17, 2011

Published: January 1, 2012

doi:10.5539/ach.v4n1p65

URL: <http://dx.doi.org/10.5539/ach.v4n1p65>

## Abstract

Building design based on principles of architecture in harmony with the climate of each region, in addition to creating thermal comfort in building interiors, reduces fuel consumption and more important it will demonstrate a clean and green environment. This issue becomes more intense in some geological areas like Khoramshahr in Iran, which has a warm, tropical and critical climate, since if this issue is not taking into account, using air conditioning utilities would be necessary in most periods of the year. According to the studies, buildings in harmony with the climate of Khoramshahr will be able to adjust the thermal conditions of their interiors naturally to the human comfort level in 82 % of cases during a year. In such a building, only in 18% of cases during a year, using mechanical systems for cooling the internal spaces is essential. The main problem in this climate is cooling the interior spaces in hot season but in winter these spaces can be kept warm at the level of comfort by using passive or active solar energy or by using simple thermal devices in some situations. This all issues give a good answer to the rules of green architecture which they were carried out by traditional architects as well. Research method of this paper is mainly descriptive and analytical which study the traditional housing of Khoramshahr has been considered for achieving climatic design principles. The results of the studies show that the most problematic issue in this climate is the dry and dusty wind in summer. Since in winter, using solar cooling systems perform a situation that restricts unfavorable climatic factors. In this paper both of above mentioned issues were solved through some guidelines in the area of green architecture.

**Keywords:** Climatic design, Green architecture, Khoramshahr, Traditional housing

## 1. Introduction

Studies has shown that being careless about climate and not reflecting it in buildings make it no prevention to use mechanical systems in order to supply comfort circumstances in buildings. This issue not only has increased families' costs, but also has made environmental destruction. Regarding the fact that in each country 15 to 20 percent of entirely consumed energy is allocated to residential usages, taking any action that makes decreases in energy consumption in this way-that provided to building heat output optimization-leads to great economizing in restricted natural sources and environment protection. So, it is necessary to study various regions' climatic traits and related architecture in order to fulfill mentioned goals. In some climates, during the year interior circumstance of harmonized building with climate remains with situation as human comfort naturally and with no need to mechanical systems. In cities such as Khoramshahr with critical climate (due to hot and sultry weather, dusty and hot winds) it is not easy to regulate interior circumstances of unharmonious buildings with climate for human comfort, and it is necessary to use controlling equipments for interior spaces at most times of year; Whereas, in the event that building has harmony with climatic circumstances and uses natural powers of the region, weather of interior spaces is often suitable and just in a few times it has need to mechanical systems. Therefore, it could prepare appropriate situation by optimization use of present climatic circumstances and by reasonable costs. Regarding what was mentioned, it is necessary in this city to make housing in conformity with region climate. Considering the fact that one of the most important purposes in architecture and building design is to supply natural and physical comfort for inhabitants, studying human effects, housing and climate factors are inevitable. In this way, after studying Khoramshahr climatic circumstances, effects of these climatic elements on

human and then on building has been provided, and finally criteria and various elements of residents and housing complexes have been explained in detail regarding residential building thermal requirements in Khoramshahr.

## 2. Studying the Climatic and Meteorology Circumstances in Khoramshahr

Khoramshahr city has located in south-west of Khuzestan province, alongside of Karoon River and has 5 meters height of free seas. Although annual raining rate is very low, this city is one of the most verdant cities in Khuzestan province (Mandan consulting engineers, 1988:5). In general, hot weather, relatively high moisture, drastic sunlight and dusty winds are important meteorology factors, and palm trees, low latitude, low height and nearness to river are significant climatic factors. In this city according to statistics of Khoramshahr climatology station each of the city climatic factors is studied. It is notable that statistics of Khoramshahr meteorology station has no data about wind blowing field, therefore Abadan station data which has a identical circumstances has been used.

## 3. Study of Khoramshahr Climatic Traits in Accordance with Human Comfort

Human thermal comfort is a situation that human has mental and physical comfortable conditions. "Thermal neutrality" is more exact phrase for thermal comfort because in this situation human body neither has feeling about heat nor coldness and hardness due to straight sunlight or drought weather and other factors (Watson, 1993:29).

### 3.1 Khoramshahr climatic traits according to kasmaee

According to Kasmaee studies, Khoramshahr has been placed on climatic group titled "Cool, Moist and semi-hot". It means that average of daily temperature and relative moisture in the coldest month of year is under sun function, but average of maximal temperature and relative moisture minimum is around sun function, and also it can make appropriate thermal circumstances by solar energy and lead sunshine into interior spaces (Kasmaee, 1993:68 and 91). Also in the most of hot months of year, average of maximal temperature and relative moisture minimum is out of shadow limit function and air current and in this situation it is impossible to control external spaces in extent of appropriate naturally (Kasmaee, 1993:62).

### 3.2 Khoramshahr climatic traits according to Olgyay bioclimatic table

According to Olgyay divisions, Khuzestan has been placed on climatic group titled "very hot summer and moist summer and without winter". By transferring summer and winter circumstances of Khoramshahr city on bioclimatic table (Figure 1), it has been resulted that in 6 months of the year (May to September) final limits of weather thermal circumstances is out of comfort area and has a long distance with upper limit (bright shadow area), and sometimes it could not make cold the weather of city by natural methods in limits of human comfort and we have to use mechanic cryogenic instruments, but in winter situations it may make weather hot by sun thermal energy (Figure 1).

### 3.3 Khoramshahr climatic traits according to Mahoney criteria

Mahoney has suggested tables in order to determine respects of various factors in climatic design. These tables have determined comfort area of night and day per month regarding to average of temperature and relative moisture, additionally cold, hot and suitable months have been separated, also it has been presented indexes as to hardships caused by climate circumstances, and finally it has presented suggestions as for various cases of design (Razjooyan, 1988:71). In this part, we draw and analyze Mahoney table for Khoramshahr based on meteorology statistics.

Khoramshahr has been divided in various months of year in groups 2, 3 and 4. With transformation of comfort limits and thermal position in night and day, various months thermal position has been divided to 3 classes of hot, appropriate and cold.

Concerning obtained results, in 4 months of year (June to September) weather is hot either at day or night, so it must prevent from heat entrance by some optimizations (thermal conductor). In 3 months of the year (April, May, June), weather is appropriate either at night or day; therefore additionally former work method, to use coldness of weather at night, it could use free space to sleep, in 2 months of the year (November and March) weather is appropriate at day and it is cold at night. In other 3 months of year (December to February, without regarding effects of sunshine heat-giving, weather is cold at day and night that thermal conductor is suggested in this case.

### 3.4 Khoramshahr climatic traits according to Evans criteria

In Mahoney method, it hasn't been considered influence of changes of air current, therefore Evans has presented table as to determine comfort area, relation of weather dry temperature with 4 factors of relative moisture, air current (0.1 to 1 m/s), type of activity, and type of clothing (Evans, 1980:36,37). To assess Khoramshahr thermal

position in this way, at the beginning in return to average of relative moisture minimum per month, comfort limits of the month days and in return to average of relative moisture maximal per month, comfort limits of the month nights, is obtained. Then average of per month temperature maximal was compared with day comfort area and average of per month temperature minimum was compared with night comfort area, thermal position of per month days and nights is obtaining with more accuracy than Mahoney method in three scales of hot, appropriate, cold. Finally, necessary guidelines are obtained in order to accommodation architecture with the region climate.

According to results of Evans's tables, Khoramshahr was in cold day thermal position at months of December to February, at March and December days were comfortable and in limits of comfort, and it is hot in other months. It is cold at nights of November to March, except June to August that the weather is hot; other months are around comfort limits.

#### **4. Khoramshahr Climatic Traits in Relation with Building**

Amount of effects of climatic circumstances in interior spaces of building depends on type and scale of building, building traits, and its external walls. In the interim, residential buildings are most impressionable building against climatic circumstances due to function simplicity and their small scale. In this part, Mahoney and Givoni methods have been used to determine trait of residential building in Khoramshahr, and after determination of thermal requirements in Khoramshahr thermal circumstances, responding methods to these requirements in shape of residential complex elements and parts has been suggested.

##### *4.1 Building climatic traits in Khoramshahr, Mahoney Criteria*

According to Mahoney method, Khoramshahr is placed in Group 1 from 23 climatic groups of Iran with building main elements traits as follows:

1. Shape of Building placement: Building would be longer along westerner-easterner side.
2. Spacing among buildings: Compact and dense context is more appropriate.
3. Air Current: Making constantly air current in interior spaces (drought) has no necessity.
4. Detachable parts Sizes: Small detachable sizes are more appropriate. It is better to their area would be between 15 to 25 percent of area of related surface.
5. Detachable situation: Because of this material that drought has no necessity in interior spaces, buildings may be formed one-sided.
6. Wall and roof: Interior and exterior walls and roofs shall be made by heavy materials with delay time more than 8 hours (or has suitable thermal conductor).
7. External Space: Because of being suitable in 5 months of year, it should predict some spaces out of the building space in order to use in these situation.

##### *4.2 Building climatic traits in Khoramshahr, Givoni Criteria*

According to this method, most of the Khuzestan cities have allocated on group 7 out of 8 groups with trait of modest winter and hot and semi-dry summer, and Khoramshahr city has placed on subgroup 31 titled climate of "modest –drastic hot and semi moist". It means that its weather in winter circumstances is around inactive sunny architecture function (designed building elements and parts in order to absorb, store, and use solar energy), and in summer circumstances it is out of water cooler function, heavy construction materials, and weather drought (Kasmaee 1992:144and146). So the main problem in this city is controlling and decreasing temperature in summer season that is possible by mechanical systems. By transformation of thermal position, all year months are obtained in bioclimatic table. According to this diagram in 3 months of the year (June to August), limits of changes of thermal circumstances is out of comfort area completely, and also in September it is in a short time of day (midnight till before sunrise) the weather is on comfort area. In periods of day's hours of these 4 months, it may control air interior of building by producing air current in interiors of building, or by use of thermal conductor in walls (alternative for delaying materials). Whereas, final control is possible just by using ventilator system and gassy cooler because of drastic heat and also increase in air moisture, water cooler can't help to cool the air, it is probable to appear sultry air but liquefaction never happen. Being careful in choosing appropriate materials (by use thermal conductor at the suitable place of the wall), is necessary in order to decrease sultry air effects (Budget and Planning Organization, 1998:190).

### 4.3 Building climatic traits in Khoramshahr, Kasmaee

Kasmaee has explained annual thermal requirements of a residential building or other buildings with simple function and slight thermal load in Khoramshahr by using effective thermal index. According to this, in the event that building plan would be harmonious with climatic situation of context entirely and in detail, in 82% of year situations, thermal circumstances of interior spaces of building is naturally suitable for human comfort, only in 18% of year times it is necessary to use mechanic systems in order to cool interior spaces.

### 4.4 Conclusion (Climatic Purposes in Khoramshahr Housing)

Generally speaking, in Khoramshahr with trait of drastic hot and semi-moist summer, major problem is cooling interior spaces and preventing moisture to these spaces in hot season (specially June to September and sometimes days of April, May, and October). In winter, it may warm these spaces by use of solar energy (passive solar systems), and sometimes in some days of December to February by thermal simple tools in comfort area of human. Also, protecting interior and exterior spaces from hot and fusty winds of region is necessary. Such results would obtain when building would be designed by following purposes (respectively by preference):

- 1- Preventing from effects of hot air in interior spaces of building
- 2- Protecting building from sunshine in hot times
- 3- Preventing decrease of air moisture in hot times
- 4- Preventing interior and exterior spaces of building from dusty winds
- 5- Leading sunshine to interior spaces of building in winter

## 5. Climatic Purposes Guidance of Khoramshahr Housing

“Climatic plan” means that it can produce appropriate natural environment for its users if harmony with peripheral environment and more exploitation of present natural powers was possible in place. Regarding mentioned climatic purposes in previous part, cases that their assistance in climatic design of residential complex leads to obtain those purposes are as follows:

### 5.1 Site selection

Choosing type and place of the site of the building regarding climatic view is one of the factors that can make thermal comfort in residential spaces. Not choosing lands that has incline to west or east protect building from sunshine in hot times. Moreover, choosing southerner lands leads sunshine to interior spaces of building in winter. Due to low steep lands of Khoramshahr, other more important factors are attention to local winds and Karoon River. It is suggested in this field to use southerner side of Karoon in order to housing as far as possible. One of advantages of mentioned site is to place on a point and direction that capability of favorable wind of degree 2 (West to east) after passing of Karoon River will be for maximized. Also, mentioned dominant hot and dusty wind (Sam Wind) loses some heat and dust before entering to residential complex.

### 5.2 Context of residential complex

Necessity of producing constant air current is the most important factor that influences on residential complexes shape. As it was said in Khoramshahr due to weather heat in several times of a year and lack of need to constant air current in interior spaces of building, residential complexes shape can be completely compact and buildings may be common in westerner and easterner facades that this shape help to prevent effects of hot air and dusty winds in interior spaces of building, and to protect building against sunshine in hot times.

### 5.3 Streets and pedestrian paths

Direction of streets is one of efficient factors in formation of residential places. Suitable orientation may protect building against sunshine in hot times, prevent dusty winds effect, and increase moisture in interior spaces of building. Effective factor in street orientation in Khoramshahr in respect of climate is amount of shadow that is made buildings around two sides of street on pedestrian paths at summer. Also appropriate combinations of streets in respect to regional dusty winds prevent entrance of these winds to residential context and interior spaces of building. For example, in Khoramshahr leaving open western streets in residential complexes passes favorable wind (From west to east) within complex, and causes weather drought. Furthermore, layout of streets at southeast of site can be such way that prevent unfavorable wet wind into complex. Whereas, due to not using of passing ventilation in interior spaces, main preference in streets orientation is opposition to sunshine in hot times. Measuring 1 meter wall shadow with various directions in various hours of 22<sup>nd</sup> day of June at Khoramshahr is showing that east 15 degree and west 15 degree streets has the most appropriate direction and west 30 degree and east 30 degree are in next preferences. Whereas, this amount of shadow is very little in

critical hours of day, so prediction of sunshade roofed pedestrian paths is necessary. Also, designing narrow streets and high rise buildings that their height respect to street width (H/W) is 4 to 1 will shade western and eastern facades and pedestrian paths (Brown, 2001:83).

#### *5.4 Pattern of ground involvement*

Ground involvement means building formation type in related plot of land. Building skeleton form and ground involvement pattern jointly form shape of residential complex. In respect of climate, prediction of forms with central yards (likewise traditional residences of Khoramshahr), and open interior spaces to these yard protect building against sunshine and prevent dusty winds effects in interior and exterior spaces. Other patterns including building located in middle of yard, two-sided building, or building with backyard with lack of creating compact shapes and increasing facade proportion to volume are not good responders to hard condition of such a climate.

#### *5.5 Building orientation*

In order to determine appropriate orientation for building, we always must pay attention to factors such as accessibility, inclination, ground topography, relation with neighbor building, outlook, and climatic circumstances that the present case is the most important factor in residential complexes formation in conformity with climate and it may study in relation with sunshine effect and also local wind blowing.

Appropriate direction of building in relation to sunshine in Khoramshahr is a direction that receives minimum amount of solar energy at the hot occasions and maximum amount at the cold times of the year. Southeast direction is completely converse direction for determined purposes; north direction also received minimum solar energy in the entire year. Whereas, direction of east 60 degree to west 15 degree that receives minimum amount of solar energy at the hot times of the year and receives maximum amount at the cold times of the year is the most appropriate direction for building orientation. Generally speaking, the most appropriate building orientation for one-sided building is east 15 degree, and southerner direction for two sided buildings.

To determine direction of building orientation regarding wind direction, it should recognize direction of dusty winds and favorable wind. Blowing direction of dominant winds in all year months is from northwest to southeast and direction of degree 2 wind is from west to east. Also, need to drought in Khoramshahr is in 17% of year times (nights of beginning of June to September and in some days of April and May and also January and February); but dominant winds of these months are those dusty winds. So, the only way to put these winds in use is to decrease pollution by some facilities. In order to prevent or decrease effects of dusty winds in interior and exterior spaces of buildings that are more significant than air current supply in interior spaces, the most appropriate direction is direction that is leeward direction. On the whole, regarding the fact that there is no necessity to make air current in interior spaces by dusty winds, it is suggested to choose a direction that is completely suitable in respect to wind direction (east and south 15 degree). It may decrease effects of dusty winds in interior and exterior spaces of building by making withdrawn building or surround it by high walls.

#### *5.6 Building skeleton formation*

As to control sunshine on building, building form must be compact, and east and west walls' area would be low. Therefore, using forms that are able to make reciprocal shadows on their outer surfaces including central yards has privilege. This formation effects on dusty winds control of region too. In order to reach mentioned climatic purposes, yard proportion and its dimension in relation with surrounded buildings has. Overlapped curved shape parts are showing two proportion of yard, one of them quadrangular and the other is rectangular plan 2:1 northerner-southerner. It shall be used from bottom edge for modest widths and upper edge for equatorial latitude (Brown, 2001:211). Regarding diagrams, in Khoramshahr climate extended rectangular yard in direction of northerner-southerner with respect of 2:1 is appropriate. These proportions decreases sunshine influence in summer and coldness load at this time and also receive sunshine at winter.

For controlling dusty winds of region, it shall be mentioned which wind passing on top of building has no turmoil for air in long and surrounded yards. Therefore, dust that there is more on air of ground surface has been remained outside the building and don't penetrate to inside the yard (Brown, 2001:210) (Figure 2). The maximum efficiency on this yard is at the time that its depth is no longer than twofold of building heights in direction of dominant wind; otherwise some of the wind enters in yard. Regarding Figure 2, quadrangular yard that proportion of building height to yard dimension is 1 to 1 accept minimum wind. But as to other factors and need to extension of the yard, in order to receive sunshine in necessary times, proper option is rectangular yard that its depth is twofold of building height in direction of wind, and in opposition direction of wind this proportion would be 1/1.(Figure2)

### 5.7 Landscape

One of the facilities that are necessary to this climate landscape is designing windbreakers that cause opposition to unfavorable winds, dust, and sand. Gravel particles that rise up on ground don't rise up more than 1 meter on ground surface even at time of the most severity blowing winds (Konya, 1980:72-73). So, it shall be stopped their movements by using relatively small obstacles. Blocks with 1.7 meter height in distance less than 6 meter in respect to building will be effective protections in order to control dust particles penetration (Sain, 1980:60). In this direction, yard wall with 1.7 meter height is appropriate block in villa residential buildings in Khoramshahr. Favorable green spaces are included ascendant plants scrolls in west wall of the building (with possibility to wind passing among leaves), long Khazandar trees in south of building in order to shade on wall and roof, also dense and short and evergreen trees on west facades for protecting building against sunshine in hot days and also prevent wind effect on building. Making appropriate distance between these trees and external walls affects on preventing hot air influence in interior spaces. Also, it shall be prevent intensification of air moisture by using penetrable materials in streets floor and areas around building, devising roofed streams, and avoiding abnama (a system of mountains and reflecting pools) prediction or vegetation groups in parts of area that it is probable to wind blow and leads this moisture inside the building.

### 5.8 Plan design

Plan development in easterner-westerner axis affects on sunshine leading to interior spaces of building, surrounded parking in west side of building, separating hot and moist spaces such as kitchen, bathroom, and laundry room from other residential spaces in plan, and also complete ventilation of these spaces prevent hot air effect and moisture in interior spaces of building (Ghobadian, 2003:124). Building depth would be in some ways that penetrates appropriate sun in interior spaces. Predicting balcony, terrace, or protected external spaces against wind in shadowed or sunshiny forms is necessary in this climate at necessary times (times that outer air is good).

### 5.9 Windows and sunshades

According to Mahoney suggestion, small windows with area of 15 to 25 percent of related facade area are good responses for building thermal requirements in this climate. Nonetheless, in Khoramshahr traditional buildings windows are relatively big and were acting with special design against wind and sunshine. Big windows are suitable when air is suitable such as winter, but in summer it is better to have less number of windows with lower size in external facades. It may be used wooden and glasses mixed windows measuring 25 to 40 percent of building facades. To reply different thermal needs in this climate, in someway about 10 to 15 percent of area thereof is glasses and the remainder would be wood. Also it is suitable to use windows with measuring 15 to 40 percent of building that is suitable with open wooden channels on outer surface. Overall, in designing residential building windows in Khoramshahr it should prevent western and southern windows as far as possible and it is better to use horizontal kinds of windows (short height and long length). It is better that windows have wiry net, and windows frame has been formed by wood or other resistance materials against heat transform (Koch-Nielsen, 2002:77). Also, all windows and bright parts should have external sunshade including materials with low thermal capacity and in bright colors (shine reflectors), and their under surface would be in dark color. Referred to Fayaz descriptions (Fayaz, 2003:77), dimension of these sunshades are measured according to suitable orientation of one-sided and two-sided buildings in Khoramshahr (southern and southeastern 15 degree). In addition to fixed sunshades, united or venetian blinds wooden front of windows, fly nets, and matting obstacles are necessary in order to prevent heat entrance and also shine at hot times and make ventilation possible at nights.

## 6. Conclusion

Studying traditional buildings of Khoramshahr has been demonstrated that choosing heavy materials with high thermal capacity, vegetation for floor making and area around building, and two-layer systems on roof and east or west facades and ventilation between two layers decrease hot air influence in interior spaces of building. Also, bright colors and surfaces relatively tough absorption factor absorption coefficient of less sunlight on roof surface and external walls protect building against sunshine and still guide sunlight into interior spaces in winter. Because of increase of air temperature and decrease of daily oscillation and specially economics problems, it couldn't make appropriate thermal circumstances in interior spaces of residential buildings of Khoramshahr only by using appropriate construction materials. Nonetheless, utilizing them would increase economical output for building cooler system and decrease rate of needful oil. Today, it is common to use thermal conductors instead of heavy materials with long width and these conductors also prevent water liquefaction (in drastic hot and semi moist climate of Khoramshahr) on walls. Generally, the most suitable suggestive construction for building walls in this climate includes surface with bright color (offered materials are bricks and coating cement), layer with one kind of thermal conductors, and interior filling wall (preferably bricks). Necessity of thermal conductor in

this region, location and thickness thereof would be analyzing carefully as following. (Kasmaee and others 2009: 9). Suggested thermal conductor is extended polystyrene (unlit or plastofom) with thermal guidance coefficient  $0/058 \text{ W/m}^{\circ}\text{c}$  ( $\lambda$ ). Analyze method has been used in this research to determine needed thermal conductor thickness in different walls of building, with obtaining minimum thermal resistance ( $R'$ ) of various walls and measure thermal resistance f different layers of per wall, needed polystyrene thermal resistance and then thickness thereof in different alls of the building are measured as follows.

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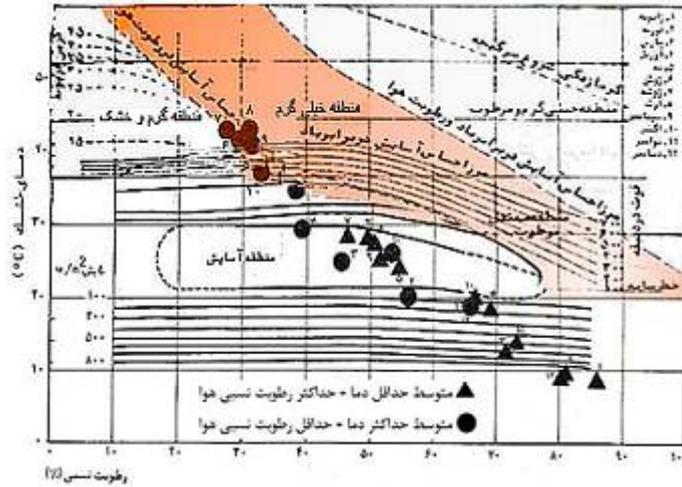


Figure 1. Bioclimatic table (Kasmaee, 1990:5)

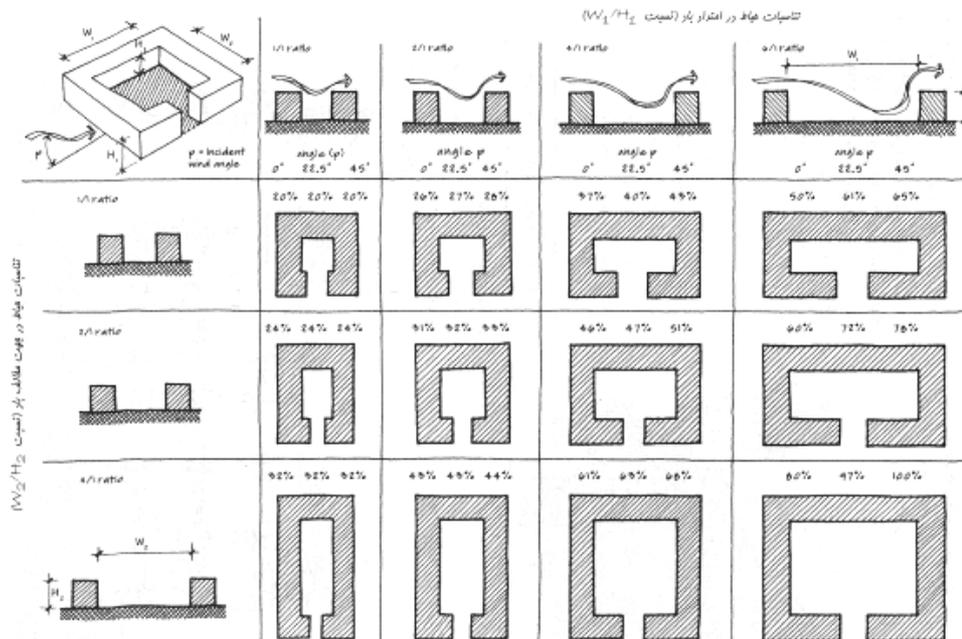


Figure 2. Yard measurements determination to ventilate (Brown, 2001:210)