

529: Climatic Study of cold dwelling (Case study: Hamedan city)

Faezeh Etemad Sheykholeslami^{1*}, Mansoreh Tahbaz²

Art and architecture, Bo-Ali Sina and Hamedan Islamic Azad, Hamedan, Iran^{1*}
F_ete@yahoo.com

Architecture & urbanism, Shahid Beheshti, Tehran, Iran²

Abstract

Hamedan dwelling is studied in climatic vision in 3 sections to achieve thermal comfort. At first, climatic features of Hamedan are considered to analyze climate condition in this city. Then typology of Hamedan dwelling is done to recognize dwelling patterns in Hamedan. At last climate analysis of Hamedan dwelling is done to achieve the sample of climatic design in Hamedan dwelling and in general in cold climate. Typology of Hamedan dwelling classifies three periods including old, middle and modern houses. Climatic analysis of these building types that we can see in native buildings is done in two sections: 1. general features of dwelling, 2. dwelling space features. General features of dwelling involve the relationship of mass and space, building settlement and building orientation. Analysis of dwelling spaces features is done about outside spaces, inside spaces and half open spaces. At last, principles of climatic design are commanded for every pattern of dwelling. This method can be used for other cities.

Keywords: thermal comfort, native building, Seizan, heating degree days

1. Introduction

Human tendency is continual in every time to climatic design, because he or she wants to have comfort in the house. Thermal comfort emanates from thermal equilibrium between human body and environment. Because building is the third skin in definition, suitable design of building on the basis of climate conditions is so important. Natural and mechanical methods are used to achieve comfort climate. Because energy sources that can refresh are limited, cities are polluted and environment is irreparably damaged of fossil fuel, natural energy must be used. This kind of energy is healthy and able to refresh. There are two methods to use natural energy. One of them is passive method that isn't used energy transformer. Human societies have achieved it based on their experience. They have used native methods in design of building, for example in mass and space, orientation and settlement of building. This method is noteworthy in this research.

2. Climate study of Hamedan city

Hamedan city is in the Alvand mountain zone in Iran and in high mountainous climate [1]. It is located at 1741.5 M and 34 52 N and 48 32 E.

2.1. Climatic categories

Climatological data for the period 1994-2003 from Hamedan Forodgah station of Iran meteorological Organization [2] is seen Air temperature, relative humidity, wind direction and the days with sunshine rain and snow. (Table 1)

2.2 Analysis of climatic condition

The study of heating and cooling degree days (related to 18 and 21) and the comparison of their ratio in Hamedan show 92% of heating need

against 8% of cooling need. On the other hand, heating is the most important problem in this cold city.

Table1.Climatological normals for the period 1994-2003

AIR TEMPERATURE	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
MAXIMUM AIR TEMPERATURE	4.3	8.9	12.2	18.5	23.9	30.1	34.1	34.7	28.3	22.2	13.3	7.1
MINIMUM AIR TEMPERATURE	0.4	4.6	-0.7	4.6	7.7	11.1	14.7	14.1	8.8	4.9	0.2	3.7
AVERAGE DEVIATION TEMPERATURE	10.7	11.4	12.9	13.9	16.2	19	19.5	20.6	20.5	17.4	13.1	10.9

THE MOST OF MAXIMUM AIR TEMPERATURE: 34.7, ANNUAL AIR TEMPERATURE: 12
THE LEAST OF MINIMUM AIR TEMPERATURE: -6.4, ANNUAL DEVIATION: 41.1

RELATIVE HUMIDITY (MEAN %)	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
RELATIVE HUMIDITY (MEAN% @3UTC)	86	83	79	76	74	65	58	52	56	68	78	84
RELATIVE HUMIDITY (MEAN% @9UTC)	67	59	45	39	33	29	28	23	23	31	49	62

AMOUNT OF PRECIPITATION MM.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
308 ANNUAL	31.6	41.9	50.4	45.2	20.3	4	3.7	1.3	0.9	22.7	41.8	44.2

The bioclimatic diagram and climate need calendar give perfect date of climate condition and needs in every city every time of day-night and seasons of year.

Givoni diagram that is one of interior comfort standard is suitable for climatic evaluation inside the dwelling, because this diagram has been designed for a person relaxing with light cloth inside the building and regarding the influence of building walls.

Drawing of temperature and humidity data on Givoni bioclimatic diagram [10] (Fig.1) shows need to use heating equipment or active and passive sun systems about 7 month a year (55%

of year). There isn't need to use cooling equipment (45% of a year), if building materials that are suitable with cold climate and cross ventilation are used. The weather is mild 29% of this time.

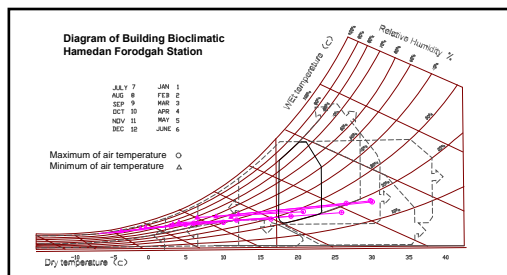


Fig 1. Givoni bioclimatic diagram of Hamedan city [10]

Climate need calendar (Fig. 2) shows dispersion of zone with the same temperature in a year and determines the time that all persons have similar thermal sense in. Hamedan climate need calendar shows that winter coldness is the main problem of all part of year in this city. Temperature decreases below zero in 3.5 to 4.5 months a year. Winter takes 4.5 to 6 months in this city and air temperature is below 4 and wind chill factor condition is possible to occur. Because of that, it is necessary to protect the building against cold wind of west south. There is need to use heating equipment in buildings about 7 to 9.5 months in a year. Efficiency of thermal capacitor materials all the year shows the necessity of using geothermal energy and the wall of capacitor. There is need to have shadow with appropriate design in 5 months from 9 a.m. to 5.5 p.m. Cross ventilation is necessary in 4 months in a year to use suitable wind of east south and west south. [3]

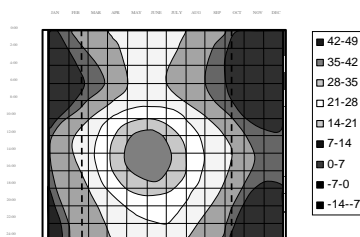


Fig 2. Climatic need calendar of Hamedan

Generally, suggestive principle on the basis of Hamedan climate analysis is 1. Maximum absorption of sun, 2. Minimum heat wasting, 3. Avoidance of winter coldness existing in majority of a year, 4. Resistance against long-time freezing, 5. Protection of building against cold wind (west south).

Therefore, heat exchange must be decreased to minimum from walls, roof and openings in buildings so that heat waste can be prevented. Also sun radiation must be used maximum for heating, penetration of cold wind to building must be prevented, the problem of snow and freezing must be decreased, cross ventilation must be used necessary time and shadow must be controlled. [4]

3. Climatic dwellings in Hamedan

Climatic dwellings in Hamedan are analyzed in two sections: 1. Typology of dwelling and 2. Climatic analysis of dwelling.

3.1. Typology of Hamedan dwelling

Activities and behaviours, which happen in every place, determine dominant structures on the place. Hamedan houses that have been built in different periods and existed are 70 types, including native and modern houses.

Main factors used to evaluate types and classify patterns are 1. General features of dwelling (relationship between mass and space, building settlement and orientation), 2. Features of dwelling spaces (open spaces, half-open spaces and closed spaces). Three periods in Hamedan dwelling are recognized on the basis of major differences in these features.

3.1.1. Dwelling in the first period: Hamedan old dwelling

There are important differences between native houses in Hamedan and houses with well known pattern seen in most cities in Iran, nowadays. Native houses in every city are old houses that follow the pattern of Islamic (traditional architecture in Iran). This main pattern changes in every place based on climate and culture in that place. Native dwellings in Hamedan are 70 or even 100 years old.

- The first pattern

These dwellings are built with central yard pattern (winter house in north part and summer house in south part of a house) in two or three floors. Yard is the junction of all spaces and is heart of the house. Porch usually conjunct bio spaces to yard, which is half-open space and filter of heat exchange.



Fig 3. The house in the first period

- The second pattern

Houses are generally built with one-side pattern or "L" form and their yards have more limited functions in comparison with the first pattern. Service spaces built around the yard in the first pattern are abridged, even only lavatory and small store remain far from the other spaces in yard. (Fig. 4 – plan) Spaces generally have interior relation through the yard or the porch and there are accesses to other spaces without going out of closed spaces. Facades are generally in a two dimensional plane and porch isn't emptied from the home volume, but is added to volume. A part of facade repeats and organizes the whole. In facade, bio spaces are the same as each other and bio-service space are the same as each

other too. This is seen with repeated frames and multi-openings in facades that organize special rhythm. (Fig. 4- facade) Generally the most important principles in old houses are:



Fig 4. The house in the second period

- ✓ Dwelling spaces are arranged and built around the yard and take view, ventilation and access by the yard.
- ✓ Yard and interior facade are built orderly and geometrically and irregularities are solved in closed spaces.
- ✓ Dwelling spaces in an internally-directed are generally divided into main zones of winter house and summer house.
- ✓ Bio spaces (main spaces) such as chamber, porch and rooms are built around the yard and service spaces such as lavatory are set behind main spaces.
- ✓ Bio-service spaces are set in the lowest level (basement or ground floor) and are used as bio spaces in very cold or very hot time.
- ✓ Service spaces like kitchen and lavatory are set in ground floor or corner of the yard. These spaces are one-function and the other spaces are multi- functions.
- ✓ Spaces are without furniture and fixed equipment. It helps the spaces to be multi-functional.
- ✓ Structure is carrier wall and major usage materials are brick, stone, wood and thatch. Wood hank is seen in some houses. [5]



Fig 5. The comparison of windows toward the yard and the road

3.1.2. Dwelling in the second period: middle period houses (transformation)

This period is a transformation stage between old and modern houses that are generally 30 to 70 years old.

- First pattern
Yard is a bio-service space. There are relationship between yard and rooms with openings that lengthen to floor. The windows of main spaces are across the yard but the windows of service spaces behind bio spaces, are small and across the path to ventilation. (Fig. 5) Basement has old pattern with pond-room and stores that gently change to glasshouse. Bio-service spaces change to service spaces too. (Fig. 5 -facade) Rooms are multi-functional and some spaces join each other with opening doors.

- second pattern
Central junction (yard) in last pattern changes to hall. Hall is a space in the centre of house and doesn't directly receive natural light. It arranges and conjuncts other spaces and entertains family majority of time. Hall is the most widely used place of house and replaces yard in old house. Therefore, the heart of house changes from an open and light space to a closed space. Hall is joined with front room across the yard and receives suitable light and view. Generally bio-service spaces included yard, porch, hall, kitchen and spaces in basement. Porch is evening seating and sleeping in summer. Entrance of automobile deletes the pond and decreases the garden in the yard. Generally the most important principles of house in the second period are:
 - ✓ Houses are built with pattern of one-sided house.
 - ✓ Closed spaces are related with a closed interior space (hall) in the centre of the house instead of yard.
 - ✓ Bio (main) spaces are built in the best side of house and service spaces are set in the basement or behind of main spaces.
 - ✓ Bio-service spaces are set beside bio spaces.
 - ✓ Service-health spaces gradually are design inside the house beside bio spaces but other service spaces the same as store and installation are set in grand floor or basement.
 - ✓ The separation of spaces based on function is comparatively done in houses.
 - ✓ View, ventilation and accessory of spaces are accomplished from the yard and road too.
 - ✓ Structure is metal with barrel vault and major materials are brick, metal and cement.

3.1.3. The third period: Hamedan modern houses

Houses in this period are mostly built from 30 years ago. Gradually apartment pattern has become dominant pattern of house that is current in ten recent years especially in five recent years in Hamedan.

This city is orient toward the south. In yard function of light and sun radiation inception is increased and bio- service function is decreased very much. Bio spaces and bio-service spaces are set beside each other because house shrinks and manner of life changes. Service spaces that are not healthy spaces (as like as store, installation and parking) are transmit to basement. Two patterns are seen in this period:

- First pattern: personable houses
These houses have two or three floors with basement. Leaving room has the most usage in house. One or two rooms are generally private spaces for children because of their study situation. Other rooms that generally haven't any furniture, are shared with family and. One bed room and kitchen generally lighten from patio. (Fig. 6) This pattern is used half-traditional family and is the most custom pattern in Hamedan. In fact the most possibility pattern of house nowadays is this pattern.

▪ second pattern: apartment

Infrastructure of house is decrease comparison with last pattern to solve economic problem and is mostly divided two to four unit in a floor. This pattern was current in the 1380s in Hamedan. In this pattern, yard totally is changed and is ruined and becomes half-public space without creation of privet sense.



Fig6. The personal house

Fig 7. The apartment

Bio-service spaces include kitchen and dining room that joint to living and drawing room and form a bigger room (day space) that every one separately furnishes. Kitchen is separated by tiles of floor or a small wall and is generally opened to living or dining room. Bed rooms are in a zone and separate with a corridor from the day space. (Fig.7) Living and drawing room receive natural light in apartment but rooms maybe receive indirect light. Units or spaces that are behind the building without suitable light, receive indirect light. This light isn't profit in Hamedan with long time winter and make dead and depress spaces that cause mental disease.

Facade is in a two dimensional plane and set in front of interior spaces like a skin without determination what space is behind of. Facade generally is worn Granite stone and reflected windows. The most important principles in modern houses in Hamedan are:

- ✓ Spaces are sat in one side and the yard is the other side of earth fragment.
- ✓ Infrastructure is divided to some units that all of them don't receive suitable light. The houses with north light are there in this period.
- ✓ Spaces are divided to day and night or general and private part.
- ✓ The most important spaces are designed beside the yard or road and other spaces are set for from open spaces and receive indirect light.
- ✓ Spaces are mono- function, generally.
- ✓ Public spaces in a house join each other and walls are deleted.
- ✓ The high of windows decrees and their distance from floor increase.
- ✓ Windows are the same measure across yard or road.

3.2. Climatic analysis of dwelling in Hamedan

Climatic requirements of Hamedan were suggested by identifying and determine the aspects of wellbeing in this cold region. Attaining the strategies of climatic design from suggested assertions aren't independent of architectural type; therefore the available dwelling of Hamedan was examined during some eras. The architecture of each era is in influenced by some factors, one of which is recon climate. Amongst

these influencibility is the general orientation of context toward east-south (Fig. 8) continued in all eras. The existence of low depth balconies in ancient houses which allowed the maximum absorption of sun light in winter while preventing summer sun light is another sign of computability with region climate. (Fig. 9) The green house which ousted in middle periods is another climate strategy. (Fig.5) These factors necessitate the examination of available samples so that the posed strategies can be used and the problems of modern patterns are identified and solved.



Fig8. Airy figure of old texture Hamedan [6]



Fig 9. Traditional shade

3.2.1. General features of dwelling: general situation of building

General features of architecture for all three eras of Hamedan houses in three dimensions are examined based on building orientation, the manner of building settlement, empty and full spaces relationship.

A. The relationship of mass and spaces

The ancient texture of Hamedan is dense and the settlement of full and empty spaces is such that full spaces are built behind each other (Fig 8). Because there are full spaces in two north and south fronts. This play a vital role in reducing heath exchange of building with open space and the walls attached to open spaces are decreased. Organization of open and closed spaces in Hamedan houses are of great important. The relationship of court with living space is indirect, established through filter with spaces of balcony and corridor. Generally, balcony is the intermediate space between open and closed spaces and ropy is the intermediate space between half open and closed spaces.

In the middle period, full and empty spaces are placed in one row so that the passage becomes suitable for cars and the texture compression is reduced. Therefore in new and middle periods, there are two fronts which cause the heat exchange to increase, while in ancient houses the utility house was a heat filter for the back house.

B. building settlement

The floor of most ancient houses was about 40 to 80 cm lower than the street level which fades into a series of steps or ramp in entrance. (Fig. 10) Therefore the ground surrounds the houses as heat insulation and reduces the heat transfer inside and outside the house. On the other hand, the reduction of building volume to the passage causes the passage to have more sunlight.

Ancient houses consist of one floor or two with base. Winter living space, located in the base, is

subjacent to the first floor orthogonally to be enclosed with a closed space when it is cold. The base is lower than the earth level from 50 to 100 cm. the base floor is adjacent to the ground while it uses the heat of earth depth (heat fluctuation decreases with the depth increase). The walls of base are thick having little openings. These provided the minimum waste of heat in horizontal and normal surfaces. In middle and modern period houses the yard floor and street are at the same level while there is no living space for base, therefore using geothermal energy is removed. The bases of modern houses include parking and storage which reduce the temperature of the first floor due to adjacency with half cold space.

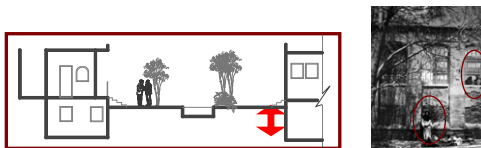


Fig 10. Going down of building to the earth

C. buildings orientation

The examination of ancient houses shows that, in houses with central yard, main orientation was towards south or east south. In some samples with denser texture, we can see orientation towards west south. In L. shaped houses, the main orientation is towards southwest and south east and the undesirable wind doesn't make any problem as the yard is small.

The general orientation of houses in middle period is toward south with a 30 degree turn to east to provide the most heat and sunlight while it was compatible with wind direction. (Fig.11) For modern houses, the orientation is towards south.



Fig 11. Orientation of old and middle houses [6].

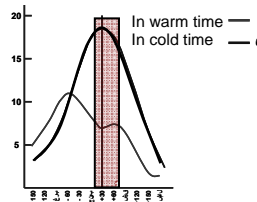


Fig 12. Absorption of heat of sun radiation in walls [7]

To identify the most suitable location of main front of building, we pay attention to sun direction and wind current. This orientation allows the house to have the least and the most warmth in summer and winter, respectively. While prevents the house from being damage by unsuitable winds. The best orientation of building is one towards south with a 30 degree turn to south (the range of 20-45 degrees) so that the building takes the least and the most warmth in summer and warmth from the sun, respectively. (Fig. 12) The front toward east is the second most suitable with respect to sun energy. [7]

If the temperature in degree 21 (the border of shadow and sunlight requirement) is aligned on the sun revolution map with Hamedan Latitude (36 degrees of north, there will be obtained three ranges of requiring the shadow in two seasons and in one season and requiring sunlight in two

season which determine the suitable orientation of building in Hamedan.

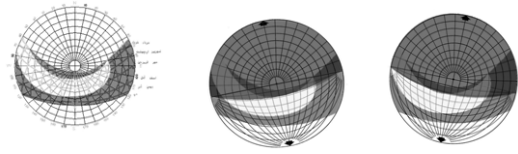


Fig 13. Time of needing to sun or shadow
Fig 14. South east and south west orientation

Overlapping the shadow finder compass and the obtained graph, we obtained the best orientation of building as 12 degree to east-south with shadow mask of 72 degree. (Fig. 14) In south-west orientation there is a warmer fall in the afternoon but in the morning of cold winters we have less sunlight. We need a deeper shadow marker in this front (83 degree for the front to south or 12 degree to west).

On the other hand, the building surrounding must be so designed so that it is protected from winter winds. [8] The wind slowing in Hamedan is dominantly to east south and for the cold wind it is west-south suitable wind blows from south-west and east. Therefore, the most suitable building orientation is east to south east of 45 degree to south. Eastern front is at the second. Generally, the best building orientation, based on absorbed radiation heat by the walls in different months, shadow maker design and wind blowing direction is south of 30 degree to east, 12 degree to east south and east to east south of 45 degree, respectively.

Now, two acceptable fronts are compared, east south and west south, to obtain the suitable orientation of dwelling texture. The south west orientation blocks the cold wind to the passages and works more efficiently.

3.2.2. Dwelling spaces feature

The constituting elements of dwelling and spatial dwelling spaces are divided into three groups of open, half open and organization closed related to free air.

A. the features of open spaces: yard

Most of the houses in Hamedan have small yard and a small pond with a plant average over to prevent the pond from freezing in cold nights. The trees planted are of fall ones to let the winter sunlight in. in middle period of north houses, the yard is used for parking and entertaining the guests, therefore the garden area is reduced and the pond removed.

The most alive part of the old houses is the yard in which utilizing and living behaviours. In the middle period, the utility function of they are dominates at present. They are makes a distance between the building to provide light and ventilation while making heat loss. (Fig.15) frost and cold wind in the east-west passage causes the neighbour house temperature to decrease.

B. the feature of open spaces: roof

The roof of houses in Hamedan is flat or inclined.

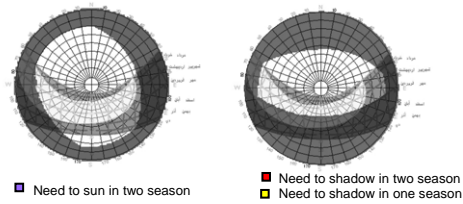


Fig 15. Shade mask of yard in modern and old houses

In the first period, the flat roof made of mud was common and then they were in parallel or in combination. Flat roofs absorbed the greatest amount of radiation which was an important factor in warming the house. The hollow space between the upper and the lower roof of inclined open performed as a heating insulation layer reducing the heat exchange. Garden houses have inclined clay roofs. Overall, inclined roofs perform more efficiently than flat ones and remove the rain easily.

C. the feature of half open spaces

The organization of closed and open spaces in the architecture of cold region and feature in Hamedan is of great importance. In the old houses, the relationship of yard with living space is indirect though balcony or corridor, the removal of which caused the heat loss.

D. closed space feature

Living spaces function in proportion with time, fuse and space performance. The deepest part of cold buildings is in north front absorbs more sunlight. And main spaces are located in this front. Sitting space with big windows is located along the yard to take the sunlight. Summer spaces are big and tall in roof to be warmed late while winter spaces are small. On the other hand, living spaces are located on kitchen and living-utility spaces to use their heat. Living spaces have windows on one side to prevent rapid current of cold wind. Internal doors of rooms are situated opposite each other to make ventilation between balcony and rooms.

Overall, rooms have small dimensions. Their small size allows more peace and integrity of spaces to make a bigger one. Therefore, most of Hamedan houses have two or three doors. The rooms located in the south, east are used for utility spaces.

Seizan (base) is laid in basement functioning as a Bio services space which includes pond room, kitchen and store. Seizan plying a vital role in Hamedan dwelling spaces and used as a winter living space with low ceiling. The low height of base and its location in the depth of the grand makes it a suitable winter living space. (Fig 16)



Fig 16. Inside and outside of Seizan

Some samples of green houses observed in middle period are capable of being used as a pattern. Corridor, the most widely used space, doesn't have direct light absorption but acts a

winter living space. In the modern period, vast spaces have made heating and cooling more difficult. Compacting spaces also lets the heat storage less in internal boltless. The spaces with similar quality of service spaces in last period became living spaces with patio.

4. Conclusion

For achieving climatic dwelling that uses natural energy to achieve thermal comfort, Hamedan dwelling has analysed in two sections. 1. Climatic study of Hamedan city and 2. Climatic study of Hamedan dwelling. These are studied to determine the climatic strategies of climatic design in Hamedan dwelling.

The climatic strategies have been using in native architecture for a long time. These are helped to decrease of thermal wasting of roof, walls and openings; to maximum use of sun radiation in winter; to decrease the influence of wind in thermal wasting; to control of long- snoozing and shading mask and also to use of cool wind in hot days.

This strategise are grammar of climatic design and lead researches and designer to achieve principles and patterns of climatic design in dwellings, after they would be adopted with nowadays needs. This method is usage for other cities and the other climate zones.

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