A Survey of Heat Dissipation in Rural vilage Housing of Cold Mountainous Climat

Shaghayegh Tabesb

Abstract--- *Due to the economic, social, cultural changes and the introduction of housing technology in Iran in the last few decades, there have been considerable changes in the housing architecture of mountainous village as one of the villages of mountainous cities. Also, these changes have transformed the image of village and increased the energy consumption in this village. Thus, by recognizing the vernacular architecture of villages to prevent heat loss through materials, we can help to improve the heat loss in the modern buildings of villages. Therefore, in order to achieve this goal, using quantitative case study and deductive method, the present study investigated the materials used in the wall and ceiling with window to floor ratio to achieve heat dissipation rate in 2 samples of vernacular housing and two samples of modern housing. Finally, the results of the study show that unlike the new buildings of the villages, the materials and architectures of vernacular housing in mountainous village have reduced the thermal dissipation by 20% due to the optimal use of climatic factors and vernacular materials (namely dried mud and wood).*

Keywords--- *Vernacular architecture, Housing typology, Thermal dissipation, mountainous Village, Cold Mountainous climate.*

I. INTRODUCTION

Vernacular architecture is a branch of architecture based on regional needs and construction materials that reflects regional traditions. (Kamyabi 2016:92). Vernacular architecture traditionally refers to human-made structures that interact wisely between human needs and environmental conditions such as climate and landform and is built by the local residents without any special skill and local materials are provided at a minimum cost. Also, vernacular architecture traditionally refers to forms that are created based on the needs of local residents and local constraints and climate (Habibi, 2005: 22). In this architecture, the building mass distribution is such that in the winter, in addition to fully gaining from the solar heat, the air flowing to outside is minimized. In the summer, while minimizing thermal conductivity, it is important to use radiation to cool the building. The building plan in winter gains solar radiation at most and in turn reduces heat conductivity considerably. (Vissilia, 2009,67-68). The development of this architecture is a relatively simple process by using local techniques and vernacular materials, and some of the functional needs of residents are fulfilled. Thus, some designers consider it as an accountable and sustainable architectural model (sutcliffe, 2009:1811). Indeed, understanding and evaluating the role of climate on traditional buildings and texture is one of the most important priorities in reducing energy consumption, using natural resources instead of mechanical systems, and creating a comfortable, healthy living environment (Tseliou, 2010, 841-842).). Due to its high latitude and exposure to climate conditions, it has dry, arid climate with temperate summers and cold winters. In addition to high altitude, the temperature range is high due to cold winters and mild climate in summers. By neglecting natural resources and renewable energy, in the near future, the

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villages will use non-renewable fossil energy. Also, these villages is shaped according to the different cultural, climatic, and cultural characteristics and this variety is observed in construction methods, plan type, installation type, type of materials, etc. (Sajjadzade, 2015). On the other hand, the architectural form of this regions is created based on maintaining the residents comfort using useful climatic elements and respect to nature and site. In the image of these villages, we can observe the respect to nature in the establishment method based on the region topography, texture formation based on nature, using wood and dried mud in construction, coating of façade, roof, etc.

In this regard, this paper aims to change the current trend and help the climate compatible-architecture for the climatic analysis of the mountainous village housing in terms of the thermal dissipation in the modern buildings of these villages in comparison to the vernacular buildings in order to find some strategies to prevent heat loss in modern buildings of these villages.

II. REVIEW OF LITERATURE

Concerning the research background related to the present study, Ahmadian (2011) believes that climatic, economic and socio-cultural factors are among the most effective factors on the formation of rural texture models that have created the highest variety of existing rural texture models .Movhed and Fatahi (2012) showed that: Rural residential units in the old village types of different areas of Fars province, while possessing some structural similarities, have a specific identity in accordance to the climatic and environmental characteristics of the village. This identity results from the influence of architectural models and factors that are introduced in this research as effective factors on the formation of rural housing. In this context, Rezayi, Wassig and Moradi (2015) showed that by field investigation of vernacular buildings of Helsem village, in which structure and texture are formed based on climate, using a small porch in the façade to enjoy breeze in the summer, construction of thick walls, small openings, the form and the establishment of building, orientation of passages and using local materials are formed basically and they are some examples of sustainable architecture principles in the rural vernacular architecture. Mohammadzade and Javanroodi (2011) revealed that despite the new buildings, vernacular architecture is successful due to optima use of climatic factors and natural resources and we can use their construction experience and techniques in the new climatic design. Rabari, Abbaszadeh, and Abron (2015) also used the descriptive-analytical and deductive method and showed that rural housing type has more than four general aspects: these four contexts include regional, geographical, social, cultural and economic conditions forming the living conditions in the houses and finally the building tradition of the rural housing.

III. RESEARCH METHODOLOGY

The study area is mountainous villages with cold climate. The study method is descriptive-field study with comparative view in two parts. In the first part, documentary and library studies form the basis for expressing, analyzing, describing, and interpreting existing items in this paper. This type of research enables the researcher to interact with the subject. In the second part, comparing the library findings of the first section with field studies and analyzing the subject conditions revealed clear results in the research. Documentary studies have been carried out based on the research purpose to evaluate the review of literature and research background. The field studies have been conducted in accordance to documentary studies, using photographic techniques and checklists from mountainous village. Also, analytical charts and graphs were used to analyze the numerical data.

Mountainous county and mountainous village

In this study, the climate of mountainous city was firstly classified using the important climatic elements and then, based on extended **de Martonne**’s classification, it was found that the city located in arid, mild climate with mild summers and cold winters. The data used in a statistical period from 1987 to 2014 were extracted from the Synoptic Station as shown in Chart (1).

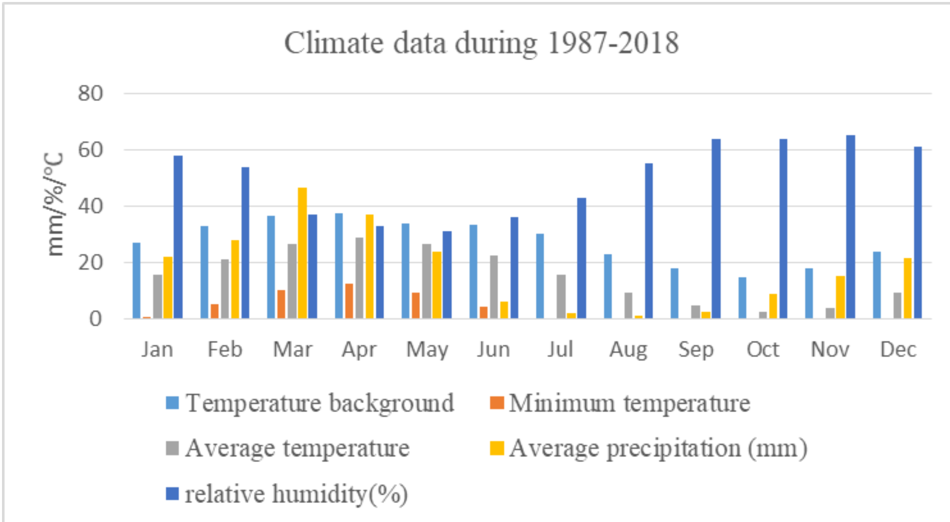

Chart 1 - Climatic data during 1987-2018, (Synoptic Station, 2019)

- **Introduce Village**

These villages are in mountainous and high sites. These villages as it is located in the mountainous areas and due to the limitation of soil resources, type of construction and village texture is as stair-shaped. Also, the architecture of residential units of villages is constructed based on the vernacular architecture of the mountainous area, climatic conditions and to avoid the thermal dissipation and wind, the buildings are constructed as compact, connected to each other to reduce the contact surface of the hot spaces of the building with the outdoor cold environment (Qobadian, 2005,99). The architecture of these villages is based on the construction methods in mountainous areas including the stair houses with flat ceiling. The required construction materials are also provided from the given region and based on the vernacular architecture. In each residential unit, warehouse and barn are considered. The orientation of the building follows the dominant wind direction and most of the windows and openings of the houses are constructed on the south (Housing Foundation of Islamic Revolution, 2011).

Generally, to determine the structural properties of the building or utility properties of various elements, constructional bioclimatic chart is used (Chart 1). One of the benefits of psychometric chart is showing that the relationship between human comfort and the thermal conditions of its surroundings based on the relationship of different climatic phenomena precisely (Kasmayi, 2009:99) According to this model, in December, January and February, to achieve the comfort zone, we should use suitable thermal and heat insulation and appropriate building materials in mountainous villages. In December days, we need humidifier. April, May and October are in the comfort zone during the day and we require active solar systems during the night. In June and July are above comfort zone during the day and we need ventilation systems and the comfort is not provided for the residents without air flow and the cooling arising from the evaporation of particles and also we need passive solar systems at night. Finally, in August and September, using mild air flow is permitted. In March, the buildings of the villages need conventional heating systems during the night and they are at comfort zone during the day.

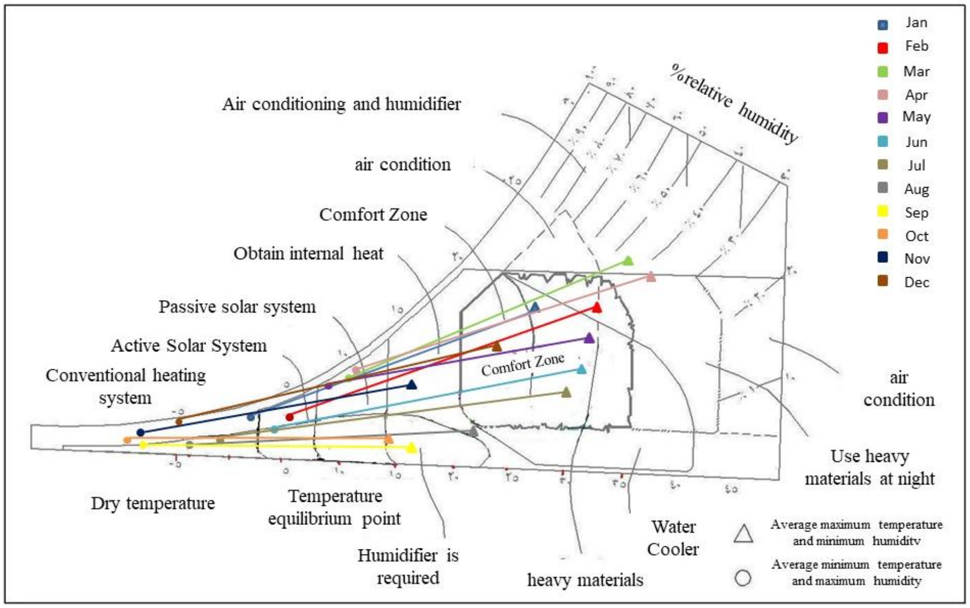

Chart 2- The bioclimatic by Gioni Index, (Author)

Generally, based on the Givoni and Mahani index, the climate of mountainous village is such that it is in comfort condition for 2 months of the year (April and October) and in Aguist, during the day, it is a the comfort zone and it needs passive heating systems during the night.

In this regard, the above comfort condition can be achieved on the following terms:

1- Hot: If the monthly average maximum or minimum temperature is higher than the upper limit of comfort (more than 20 ° C).

2- Suitable: If the monthly average maximum or minimum temperature is about the comfort zone (15 ° C to 20° C).

3-Cold: If the monthly average maximum or minimum temperature is below the lower comfort limit (less than 15 ° C).

According to the results of psychrometric indices of the mountainous village, the following results can be achieved regarding the physical conditions of the mountainous buildings and textures:

- The main front of the building is northwest and southeast.
- The materials with high thermal capacity are used.
- The walls should be thick.
- The facades have no fracture to avoid cold traps.
- Plans should be compact and the façade color is somehow dark.
- The proper surface for the opening should be 20 to 40 percent of the walls.
- The building should be compact with a square plan. Two-story buildings with cube forms are the best type of building to control indoor heat in the winter.
- Thermal insulation of exterior walls.
- The use of heavy walls is necessary to maintain indoor thermal equilibrium. Using thermal insulation on the outer surfaces of the side walls is also required to prevent heat transfer from the building to the outside.
- Minimize indoor air exchange and natural ventilation, thereby preventing indoor being cold and the internal heat exit to the outdoor.
- Because at very high latitudes, the temperature fluctuations are very low relative to its cold temperature and its deviation from the comfort zone, the use of material heat resistance is the only way to control indoor temperature.
- Select flat roofs and keep snow on roofs as thermal insulation.

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- Minimize the outer surface against the volume covered.

- **Research findings of mountainousVillage**

In this study, 2 samples of vernacular houses of villages were investigated for the use of materials in the wall and ceiling as well as for thermal dissipation through the walls, ceiling and the window to floor ratio (Table 1), they were compared with two samples of modern buildings in these villages in terms of thermal dissipation of the materials (Table 2).

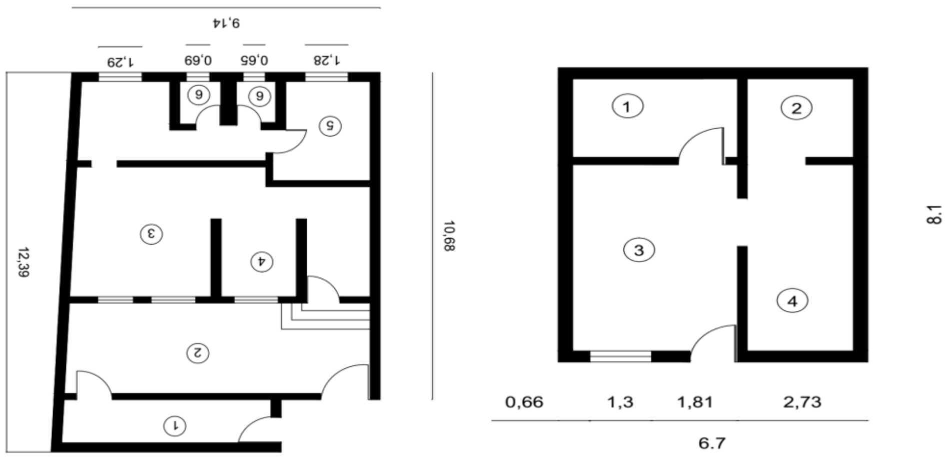


Image 1: Vernacular house plan in villages

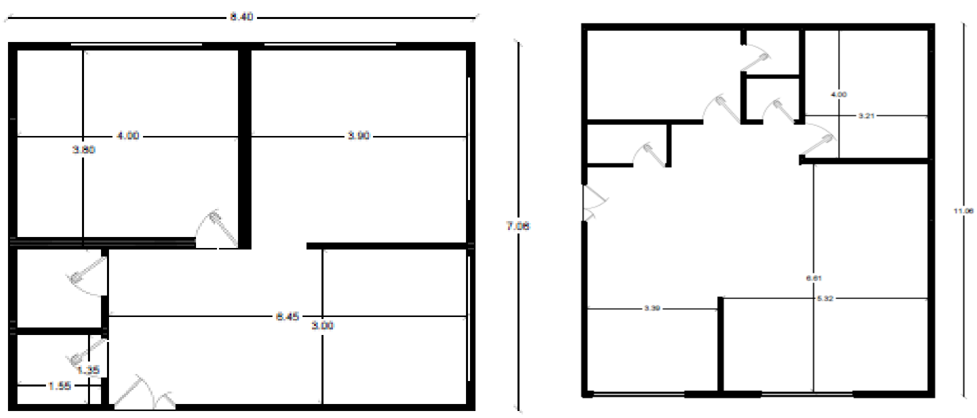
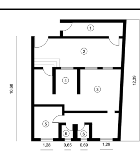
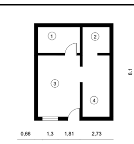


Image 2: Modern house plan in villages

Table 1- Comparison of traditional housing by heat loss through walls and ceiling in villages, (Author)

Research samples		House 1	House 2
Plan			
Texture	Traditional	*	*
Materials	Wall	Dried mud	Dried mud
	Ceiling	Wooden	Wooden

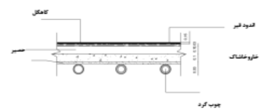
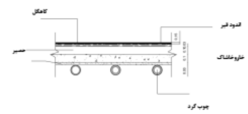
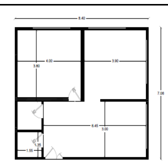
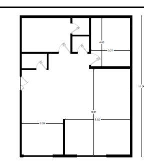
Dimensions (M)	Length	12.30	8.10
	Width	9.14	6.70
	Height	2.70	2.70
	Area	133.24	54.27
The ratio of external surface to useful volume S/V		0.37	0.37
Window to Floor ratio AW/AF		0.157	0.03
Ceiling detail			
Thermal resistance of ceiling D/λ		0.43	0.43
Thermal resistance of wall D/λ		0.45	0.45
$Q=UA\Delta T$	Ceiling	3.43	1.4
	Wall	3.59	1.46

Table 2- Comparison of modern urban housing in terms of heat dissipation through the ceiling and wall

Research samples		House 2	House 3
Plan			
Texture	Traditional	Modern	Modern
Materials	Wall	Pottery block	Brick
	Ceiling	Chromite	Composite
Dimensions (M)	Length	8.40	11.06
	Width	7.06	9.06
	Height	2.70	2.70
	Area	63.84	100.06
The ratio of external surface to useful volume S/V		0.37	0.37
Window to Floor ratio AW/AF		0.22	0.23
Thermal resistance of ceiling D/λ		1.3	1.11
Thermal resistance of wall D/λ		2.38	0.67
$Q=UA\Delta T$	Ceiling	4.9	6.6
	Wall	9.11	4.02

IV. Conclusion

The mountainous villages has been a traditional and vernacular habitat that has long attempted to utilize natural design elements and construction techniques to provide thermal comfort conditions. However, in recent years, like all other villages in Iran, the traditional texture and architecture of this villages has undergone a lot of changes with unsuitable policies and using the cheap fossil fuel subsidies, and as urban areas, the role of environmental and climatic factors has been reduced in shaping residential and non-residential spaces. This villages now has an old and new texture: traditional texture spaces more than anything indicate the application of eco-friendly techniques to the climatic conditions of regions. The design and dimension of the plans, the construction type, the distribution of spaces, the spatial relationship of materials used, the compact texture all show this reality. For this reason, mountainous villages can be described as a stable villages in terms of climate and architecture. In this regard, the study of new and traditional housing shows that in traditional villages texture, the plan form of most of the buildings is somehow square and has a relative elongation on the south-southwest side and the openings are also limited and the most open level is toward the southeast-southwest directions. The surface of opening in this villages is limited and the highest surface of opening in the southern front is located in the upper section of building. The materials also used in the texture of the vernacular walls of the mountainous villages, made of wood and dried mud, have a higher thermal capacity and thermal resistance than modern brick houses. According to the study, it was found that the vernacular houses of the villages, which consisted of dried mud walls and wooden ceiling (consisting of round timber, mats, thorn, thatch, tree branches, and tar), were compared to two modern houses of this villages that are identical in size to the vernacular houses, and are made of block and composite beam of ceiling and walls made of soil and brick blocks. It should be noted that the thermal capacity of each of these materials was extracted and calculated in accordance with the 19 national regulations on heat capacity and thermal resistance of the materials. Then, we calculated the energy loss through the wall and ceiling of the houses in the villages. According to these calculations, it is shown that in comparison of traditional and modern houses in mountainous villages; Traditional houses have less heat dissipation than modern houses in mountainous villages. Also, in the selected samples, by examining the ratio of the exterior surface to the useful volume of the building and the windows to the floor ratio, it was found that in the traditional houses in this villages, the window-to-floor ratio is less than the modern houses based on the climatic reasons mentioned. Later, we compared the energy loss through the ceiling and wall of the samples in the mountainous villages houses with the same area (Charts 3 and 4). It is observed that in all the traditional buildings in mountainous villages that are made of local materials; the amount of energy loss through walls and ceilings is much less (up to 20%) than modern rural buildings.

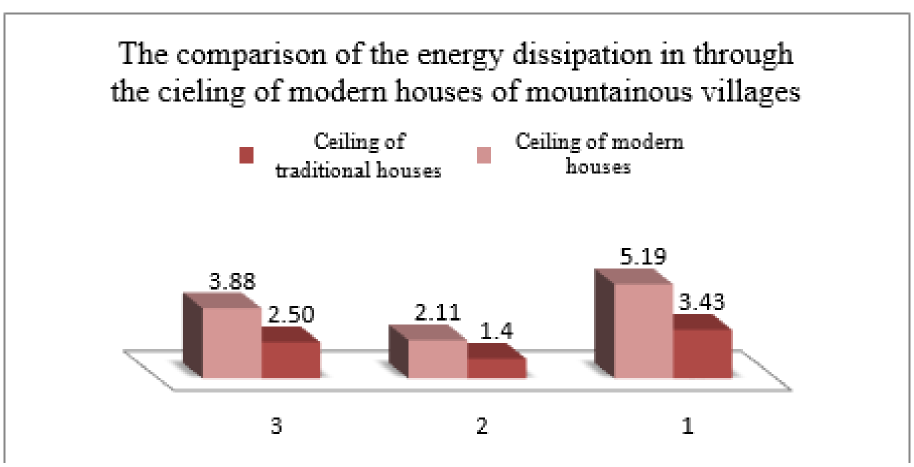


Chart 3- Comparison of energy loss in ceiling of samples (modern and traditional) of mountainous villages, (author)

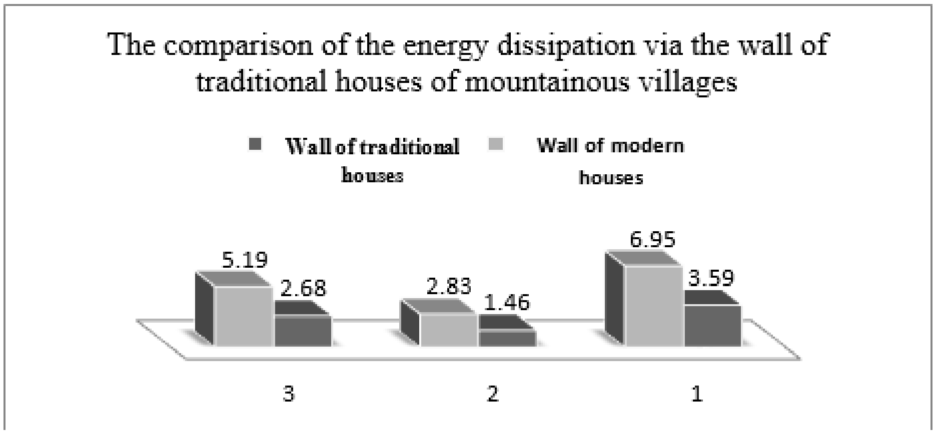


Chart 4- Comparison of the amount of energy loss via the wall of the studied (modern and traditional) samples of mountainous villages, (Author)

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