

Sustainable Energy Lessons from Domestic Architecture of Rock Villages of Cold-Dry Regions of Iran (Case Studies: Benakohul, Samarkhazan and Hilehvar Villages)

Feridoun Nahidi Azar¹, Alireza Sadeghi², Bahram Karami^{3*}, Dorna Nahidi Azar⁴

^{1,3}Department of Architecture, Shabestar Branch, Islamic Azad University, Shabestar, Iran

²Department of Architecture, Jolfa International Branch, Islamic Azad University, Jolfa, Iran

⁴Department of Architecture, Ajab Shir Branch, Islamic Azad University, Ajab Shir, Iran

ABSTRACT

Integrated design of rocky villages of Benakohul, Hilehvar and SamarKhazan with cold-dry climate of East Azerbaijan Province located in the north-west of Iran is affected by construction methods of Kohul (underground barn). These spaces involve two main parts: Kohuls with openings and Pehreh. The term of Kohul refers to conical roof (vaulted) spaces with openings and Pehreh refers to flat roof spaces without openings. The interior space of the Kohuls (by circular plan) that is dug in depth of 2 to 8 meters was designed so that provides energy comfort for adjacent residential spaces meanwhile providing oxygen and indirect ventilation for animals. Lessons learned from sustainability principles and energy dominated on mentioned organic villages have up to dating and optimal utilization capacity in contemporary rural buildings, are investigated analytically.

KEYWORDS: sustainable rock village, energy efficiency, Kohul.

INTRODUCTION

In Azeri language, Kohul means a barn within the mountain or rocks into the soil that it is dug manually under the rural houses. Most of the Kohuls were constructed inside of the houses and they were expanded under the houses and passages in different sizes depending on number of the animals as circular plan that the biggest one was 18m length, 16m width and 8 meters height. Most of the houses of these three villages do not have yard, so the roofs of the front houses play as rooftop yards for the rear houses. The entrance is located beside houses. In other words, the manner of construction of the Kohuls in East Azerbaijan Province is affected by cold and dry climate of this region, in order to reducing energy losses in winter by placement in large thermal mass within the earth (Ghobadian, 1998).

BENAKOHUL VILLAGE

Located 5 kilometers from Bostanabad, Benakohul Village is one of the districts of Bostanabad city in East Azerbaijan province. Due to being in Mountainous area, East Azerbaijan have cold & dry climate and high lands of mountains is used to solar gain; on the whole construction of the buildings and Kohuls is affected by climate and to avoid energy loss Kohuls are constructed in the heart of the mountains (figure 1). The seniors and elders of this region express that each Kohul was constructed in around 20 days by 8 men who dug the stones in hand palm size pieces by pick or hand. This village ages around 1400 years and in fact construction of the Kohuls has led to construction of it. The biggest of these Kohuls with 250 years antiquity has been 16 in 18 meters with 8meters height and is destroyed at present. There are more than 100 Kohuls in this village.



Fig.1. Organic plan of typical Kohul in Benakohul

*Corresponding Author: Bahram Karami, Department of Architecture, Shabestar Branch, Islamic Azad University, Shabestar, Iran.

The considerable point is that Kohuls enjoy very cool summers and warm winters due to being constructed in the heart of the mountain. The heat of the cattle's body and their breathing makes the inside of the Kohuls very hot in winter and since they are empty of cattle in summer, they become refrigerator-like cool and if the meat is put inside them it will freeze. Inner cover of the Kohul is made of Karan which is a local soil. The noticeable point about this soil is that, the heat and breathing of the cattle makes it to be sticky and become harder and this makes the Kohul durable; thus, if the animals won't be in it for years it will be destroyed.

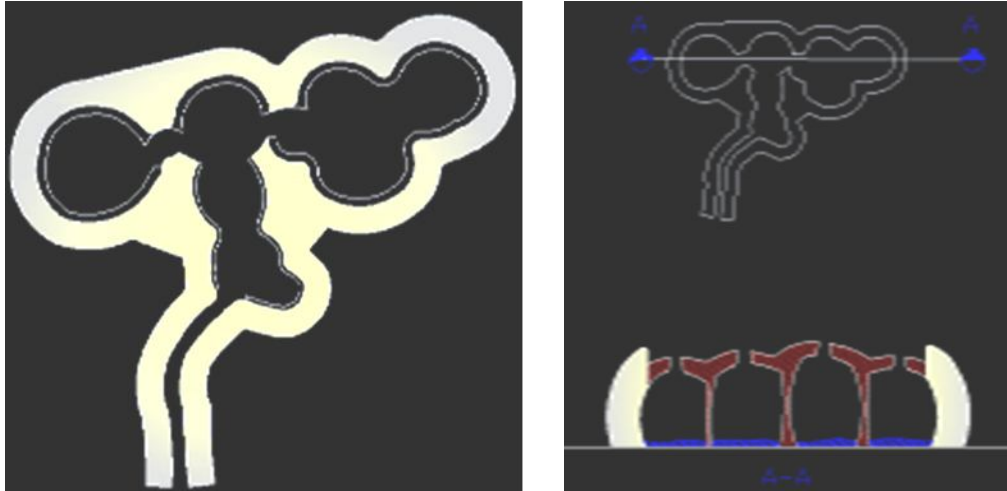


Fig.2. Organic plan and section of typical Kohul in Benakohul

Another characteristic of these Kohuls is their circular shape edge plan (figure 2, 3). The first reason is digging the mountain is circular shape with 2 to 8 meters depth and the second reason is that by this type of digging they won't have edge and angle which will prevent from waste of energy and makes it sustainable. Mangers are constructed all round the inside of these Kohuls for the animals to eat grass. The entrance of these Kohuls is not more than 2 meters and its height varies from 1 to 2 meters to minimize energy loss; therefore to enter a Kohul we should bend a little. Kohuls are composed of different parts: a) Kohuls with opening: it is clear from its name that it has opening in the roof with 70 centimeter diameter for air ventilation, b) Pehreh: is a small place with 180 centimeter height without opening and not more than 6 animals can be kept in it, c) bathroom, d) water well, e) Tin: a place for keeping poultry (Fateh, et al, 2009).

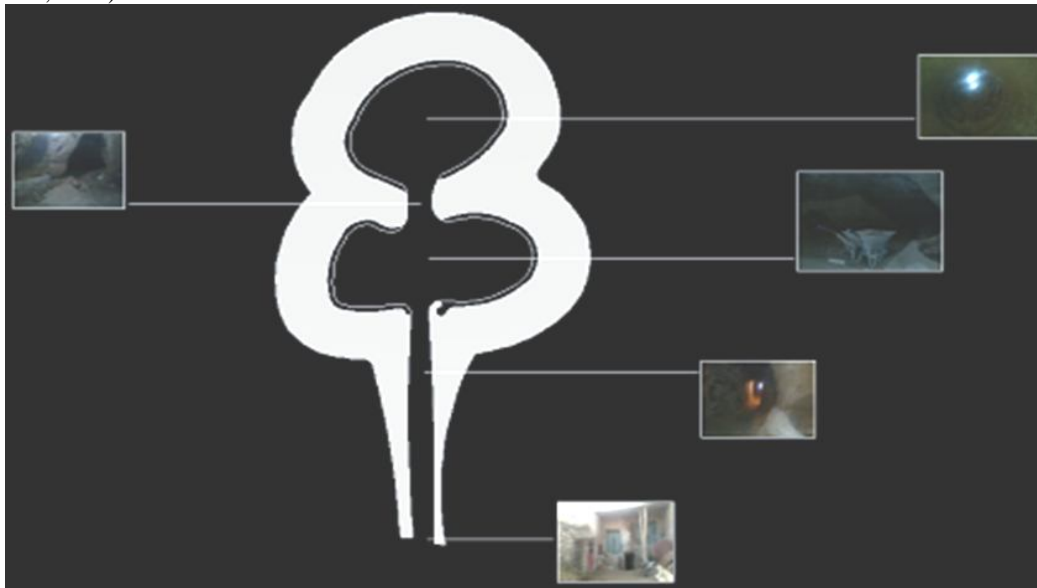


Fig.3. Kohul and related elements

SAMARKHAZAN VILLAGE

SamarKhazan Village is also one of the districts of Bostanabad in East Azerbaijan province which is located beside Sahand Mountain. SamarKhazan Village is a stair-shape village as it is located in one of the mountain feet of two adjacent mountains. According to stone carvings, the oldness of this village dates back to 200 to 250 years. Farming water of this village is supplied by a stream located beside it (figure 4).

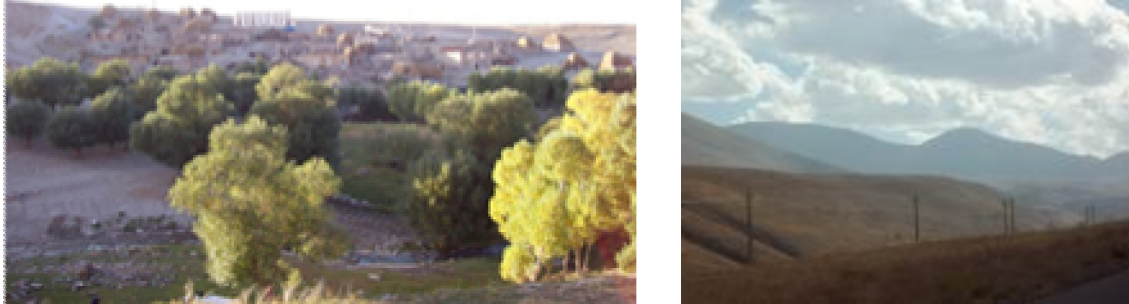


Fig.4. Views of Samarkhazan Village

Kohuls are one the important characteristics of this village. As it was said before Kohul is the place to keep cattle of the village people. It is a barn-like place with the difference that Kohul is constructed in the heart of the mountain and under the houses of the villagers. Most of the Kohuls start from inside the house and extend under the house to sidewalks of the village. Some Kohuls are big and some are small depending on the number of animals of the house owner (Shaterian, 2008). Most of the houses do not have yards in this village and the roof of the next house is considered as the yard of the previous one. The entrance of the Kohuls is placed beside the houses (figure 5).



Fig.5. Samarkhazan Village with local architecture

Plan of the Kohuls of this village is extended and rectangle shape. Approximate width of these Kohuls is 3 to 8 meters and their depth is 15 to 20 meters. Inside the Kohuls, there are a platform shape place to put cattle grass on it and a place to keep grass. On the roof of the Kohuls where they face sidewalks there are some openings for light and air ventilation (figure 6). Stones are put around these openings and sometimes grass of the cattle is poured inside through these openings.



Fig.6. Kohul opening to provide light and ventilation

The spaces with openings in their roofs are called Kohul and the spaces with no openings in the roofs are called Pehreh. Since these Kohuls are placed under the ground and near the big thermal soil mass (figure 7, 8), they are cold in summer and warm in winter. Therefore, they are used as refrigerators to produce natural cold and energy sustainability in hot weather of summer, also they are considered an ideal place for keeping cattle in winter.

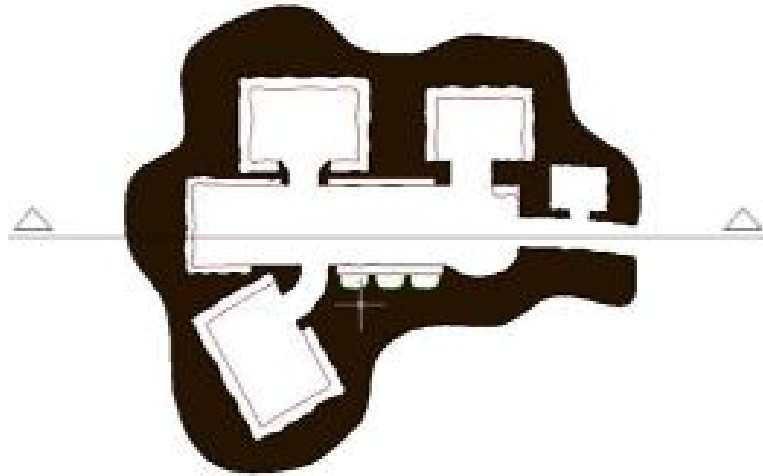


Fig.7. Kohul plan within other rural living spaces

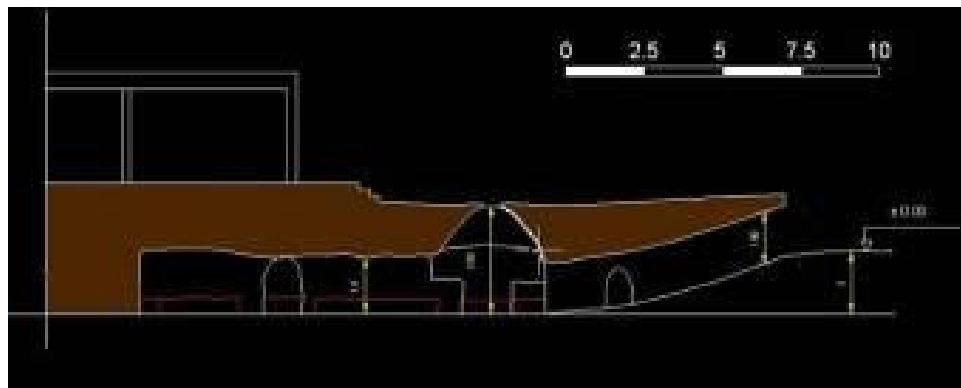


Fig.8. Kohul section within other rural living spaces

The mechanism of Kohuls is such that if they happen not to be used for several years successively, they are destroyed because whenever the cattle is in Kohul the breath and the humid produced by the cattle functions as a strong adhesive material preventing the falling of walls and ceilings of the Kohul (figure 9). That is the more these Kohuls are used the healthier they become.



Fig.9. Kohul opening to provide light and ventilation

Today because of the financial problems the villagers have and since they can't afford to buy enough cattle, the Kohuls are useless and these natural and ecological works are destroyed quickly. If this trend continues, the Kohuls must be filled or they will cause falling of the houses and sidewalks imposing a thorough damage to the whole village for they located under the sidewalks of the village (figure 10). The roof the Kohuls is cone shape but the roof of the Pehreh is plane. The height of the place to keep cattle depends on the kind of the cattle, for example the height of the spaces to keep horses, cows, sheep and poultry are different and on the whole there are different spaces in the Kohuls to keep these animals.



Fig.10. Kohul Entrance in a sample village house

HILEHVAR VILLAGE

This village is located 40 kilometers from Tabriz city in East Azarbaijan Province (figure 11) and it is abandoned now and going to be destroyed; on the whole no fence or guardsman is protecting it.

The houses of this village which are mostly like caves are located in mountain slopes 2 kilometers from historical village of Kandovan (Memarian, 2008). These houses have 3 meters tunnel as entrance and after that there is a 1.5 meters long hole as the entrance door. Inside these houses and all round them some platforms are improvised some of which are used as platforms in the houses and some are used as manger in the barns. There are candle stands on the walls of the house with 1 meter height and some holes on the walls of the barn where barn spikes were in. the inner part are made of stone and there are 10 meters long and 5 meters wide corridors without any columns or walls (Nassehzadeh et al., 2009).



Fig.11. Arial view of Hilehvar Village

There are two shapes of houses in this village. The first are the houses with the barn beside residential place and the second type are the houses where barns are under the residential place (summer) and around it (winter) (fig13, 14). In the first type houses, there is a corridor after entrance and some ditches as residential places beside which barns are located and can be accessed through corridor (Farid, 1993). The house with the residential place at top and barn under that are used in summer and in winter the barn would be around the house far from entrance door and the heat from

the stones in winter shall not be neglected. In the first type house, the barn beside the house is used in summer and the cattle are kept around the house in winter to use their heat and prevent from heat and energy loss (fig12, 13).

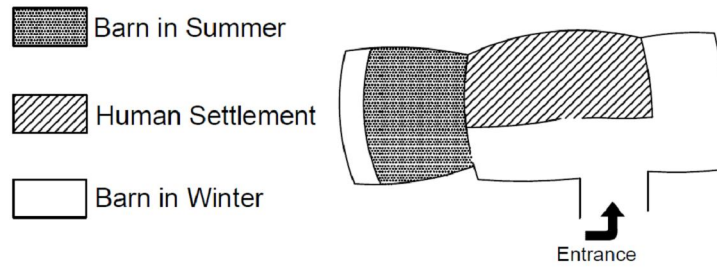


Fig.12. Plan of typical House (A)

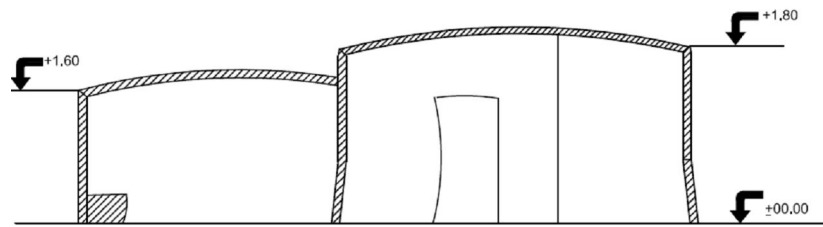


Fig.13. Section of typical House (A)

In the second type houses there are separate entrances for the house and the barn but there is an opening from house to barn. The size of this type houses is bigger than the first one (fig14, 15).

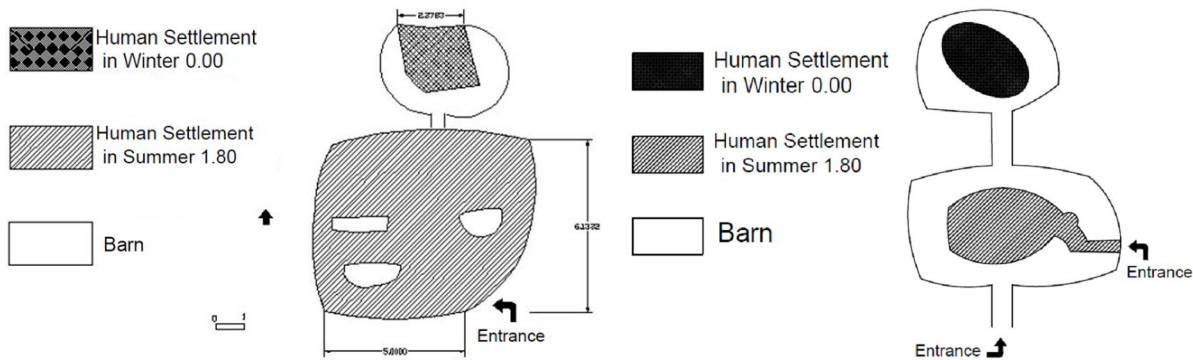


Fig.14. Plans of typical House (B)

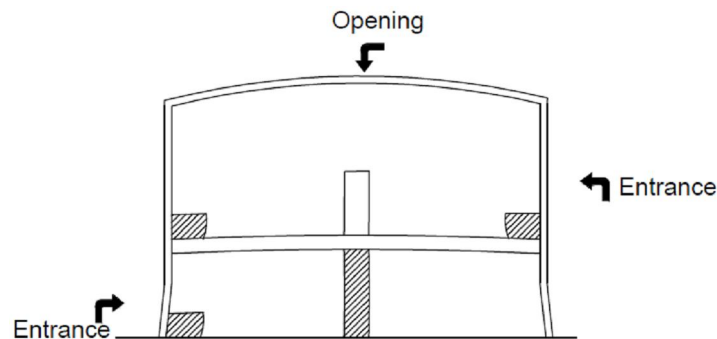


Fig.15. Section of typical House (B)

On the whole it can be said that in both form houses living type is the same in winter with this difference that in the second type the distance between living space and entrance is more than the first type.

Number of the ditches (openings) is around 47 and there are 80 meters distance from the first to the last ditch. There are big stones at the top of the last ditches are protectors and indicators.

It can be concluded that the space occupied by the cattle had been more than the space occupied by human (around 2 times) as in the first and second type houses it was as follows (Table 1, 2);

Table1. First type houses

Type of Space	Total Area (m ²)
Residential Space	7.5
Barn Space	16.5
Total Spaces	24

Table2. Second type houses

Type of Space	Total Area (m ²)
Residential Space	18
Barn Space	32
Total Spaces	50

CONCLUSION

Winter temperature within Kohuls due to body temperature and breathing animals is extremely hot and vice versa in summer, which is devoid of animals, such as refrigerators and so much cooler to keep meat is used. Kohul involves different parts like Kohul with opening (for ventilation with 70cm diameter hole in the ceiling); Pehreh (small space without opening height of 1.8 meters with capacity of six animals), Tin (hens and roosters location), bath and water well. In other hand, the ratios are considerable in Kohuls. In 2:1 ratio, the length of 16 meters and 8 meters wide, Kohul will be 4 meters high. According to studies conducted, there are two Kohuls for each Pehreh in order to supplying needed oxygen and indirect ventilation, preventing asphyxia and explosion from animal waste, and finally to lead to energy sustainability.

Kohul mechanism is if such a period of consecutive years not use it is destructed because due to animals inside Kohuls and moisture from their hot breathing acts like strong glue and causes partial stability and natural empowerment of the soil; as a result sustainability and durability increases.

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