

Typology of Earth-shelter Architecture in Iran

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ABSTRACT: Earth-Shelter construction is one of the aspects in architecture where the thermal mass of the earth behind the outer walls are applied in order to reduce heat loss and keep the internal temperature at human comfort range. In case of earth-shelter buildings, housing is especially important. As for its applicability the earth-shelter provides good housing. Typological studies of earth-shelter construction in Iran by introduces various Iranian examples of this type, could be a model for the today's innovative designs with an approach to energy saving. This type of construction responded to human comfort requirements when modernism was absent to claim that it could do the same through mechanical technology. The study method adopted here consists of qualitative-descriptive and deductive analyses. The categories of earth-shelter architecture are three worldwide: Earth Mound, Rocky or In-Hill and Bellow ground. Here the genotype of earth architecture and phenotype of earth-shelter are studied in details. The same is of two in Iran: Rocky, which is divided in continues and discontinues types and closed underground type. Studies conducted in Iran have revealed a new type of these structures named Combined Continues Rocky open Underground by the author.

Keywords: Earth-shelter, Architecture, Iran, Typology.

INTRODUCTION

Earth-Sheltered architecture uses the adjacent land as the walls of the structure as a mass to prevent hit transfer which intern keeps the internal temperature constant. This style of architecture known as the first that man adopted for housing is being pursued in parallel to the contemporary styles known as sustainable solar energy architecture (Earth Sheltering-wikipedia,2010). After the energy crises of 1970's the earth-sheltered architecture concept entered the trend of housing architecture and is evolving ever since. In the realm of Earth-Sheltered architecture the factor of energy saving has the priority. Regarding the earth-sheltered architecture the non-residential structures were built underground for reasons other than energy saving and this by no means is an indication that saving energy in this manner cannot be applied in non-residential structure (Wendt, 1982). It is obvious that such applications could provide a limited and effective utility in future.

Typological studies conducted in Iran on earth-sheltered architecture introduces various examples of this type, which could be considered as a model for today's innovative designs with respect to energy saving. This type of construction responded to human comfort requirements when modernism was absent to claim that it could do the same through mechanical technology.

MATERIALS AND METHODS

The study method here is qualitative, analytic descriptive and deductive. The analytic description would describe the physical conditions of available Earth-Sheltered structures which would lead to deductive result that would allow

comparison with the same in Iran and the world. Here the criterions on the residential earth-shelter dwellings that served as residential and defensive shelters upon need in certain times. Some of these structures served as tombs or worship centers, an issue beyond this study's realm.

The Type of Earth-Sheltered Structures and Their Physical Descriptions

Earth-Sheltered structures the historic or contemporary are of three categories worldwide.

Structures with earth mound: By compacting the soil surrounding the outer walls are formed and the ceiling is completely covered with soil. Said otherwise, in this type of structures the soil mass is dozed in a mechanical manner and the openings or cavities are formed in one or more facet (Fig.1).

Rocky Earth-Sheltered structures: Here the structure is built on the mountain or hill slopes and in their modern and optimized models their orientation is towards the equator in order to utilize the solar energy. In this formation the structure is able to absorb the maximum solar energy (Fig.2) (Wendt,1982). This type is considered as the most interesting and extraordinary Earth-Sheltered architecture style with a few thousand years old background. Here sizeable cavities are carved in the vertical rocky surface to serve as dwelling units, tombs etc. that achieved through human struggle against rock for the purpose of providing appropriate space. In its ancient form the whole body of the structure consisted of the carved rock with no other construction material involved. Unlike the conventional structures that are subject to nature's force and erode during time, these structures are resistant to those forces. Only very strong earthquake could be effective on

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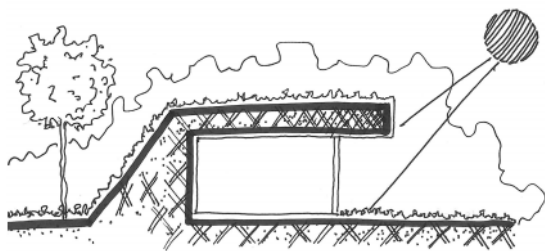


Fig.1: Structures with earth mound

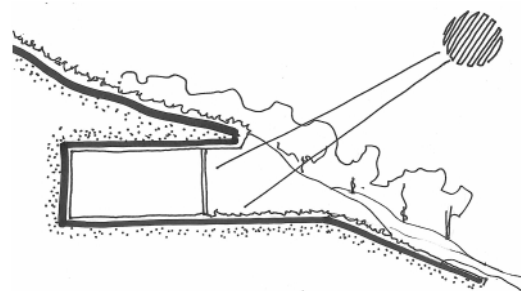


Fig. 2: Rocky Earth-Sheltered structures

such structures. Field observations indicate that out of hundreds of these structures located on seismic belts a few have been destroyed. Their durability contributes to studies of history of ancient civilization something that cannot be claimed on regular architecture (<http://forum.Persian.fun.com>).
Bellow ground Earth-Sheltered structures: These structures are excavated completely below the ground and for light and air conditioning they have a court yard at their center in a pit-shaped garden form. They are usually built in areas with high population congestion on flat grounds (Fig.3) (Wendt, 1982). The city of Magmata in Tunisia and the underground cities of Cappadocia region in today Turkey are of this type (Energy Efficiency and Renewable Energy, 1997). The light for these structures could be provided by ceiling outlet, court yard, the underground atrium or the horizontal channels made in the earth piles surrounding the space (Brown and Decky, 2008).

Ancient Earth-Sheltered Structure Complexes Worldwide

The Earth-Sheltered structures of all mentioned types in different regions of the world though similar in generality have different utilities of space, number of floors, accessibility, in harmony with nature. In Europe, the south in specific, Spain, (Minorca area), Etruria in Italy, in Greece next to a spring in Castaly and Delphi many rocky earth shelters are still available. In Tripoli region there exist a thriving rocky earth village with about 4000 population. In Turkey, the Grome valley region about 200 Km. south east Ankara exist a thriving rocky earth village. More rocky earth sheltered specimens are still in stable condition in Pontus, Phrygia and Lydia. In north-western Libiain Gharian, Nalout, and Ghadamis regions in the mountainous areas there are earth-sheltered dwellings and cities, occupied with aborigines (Golani and Ojima, 1996).

The Earth sheltered Complexes in China

A population of about forty million lives in such dwellings

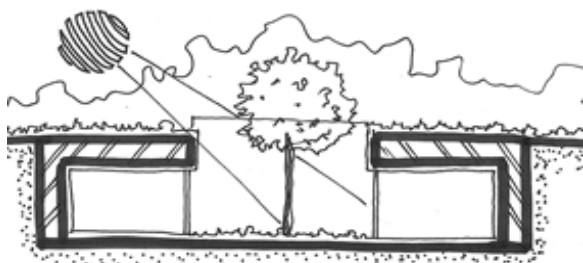


Fig.3: Bellow ground Earth-Sheltered structures

in Shanxi, Shaanxi, Henan in the eastern sections of Gansu and Ningxia autonomous regions of today’s China. According to Chines researchers some specimens are 3000 years old. In Gansu, an eastern province, 83% of the total population lives in underground earth shelters. More than 50% of the dwellings in Yanaan consist of earth-sheltered structures (Golani, 1986). The two main types of earth shelter structures: underground with central yard (Fig.4) and rocky earth shelter structure serve as dwellings. The first type is excavated in the underground in a square or rectangle shape on a flat land with rooms surrounding it. Some farmers cultivate above their shelter where staircases connect the central yard to the upper level. The rocky shelters consist of rooms with wide terraces. In such structures the southern portions are exposed to more daylight. Some of the rocky earth shelter structures represent a combination of over and underground structures (Golani and Ojima,1996).

The Earth Sheltered Complexes in Tunisia

Most of the earth sheltered structures with high concentrations are built in this North African country; while similar structures are found in Libia, Morocco and Matmata Aljazeera countries of the same continent (Ibid). In Tunisia only the underground and rocky earth sheltered structures are observed. Roman style earth shelter is common in Bulla Regia, a developed city in the north Tunisia with hot and arid Mediterranean climate in the summer and humid and cold in the winter. In the Roman ruling era this region was the wheat production center in North Africa.

The Romans built their earth shelters based on the sufficient knowledge of the underground temperature properties and applied proper techniques regarding light and ventilation. By doing so they developed a pleasant living space for the hot summer (Fig.5) (Golani,1986). The rocky structures were built for defensive purpose, since the Arab invaders attacked the dwellings from the west side of this valley (Fig.6).



Fig.4: Bellow ground houses. Gansu, China.
 (Source:<http://www.brainpickings.org/index.php/tag/anthropology>)

The Roman style structures in Bula Regia differ from that of the Matamata plateau (Fig.7). The Romans were aware of the advantages and importance of earth sheltered architecture by Berbers in North Africa. The conducted studies indicate that the Romans resorted to earth sheltered spaces during the high hit in the region. The thickness of earth crust on top of Berbers shelters is 5m; while the same is 1.5m for Romans due to their advanced techniques. The interior of the Roman made rooms' walls were covered with stone as well as their floors. They erected columned verandas in the central yard and the surrounding wings which continued to the inner backrooms in order to furnish light and ventilation (Golani and Ojima,1996).

The Earth Sheltered Complexes in Cappadocia, Turkey

This city with a 10,000 years background was called "KatalHuyuk" in the ancient times. It is located 400km south east of Ankara, Turkey with a hot and arid climate and a total of 42 earth sheltered structures of underground style. The utility of earth shelter in underground and rocky style goes back to 4,000 year. The land surface in this area is of cooled magma flow where the sharp tips of projected features are eroded into conic shapes through dry desert winds. This conic features constitute a connective network of structures. These structures in addition to dwelling purpose have served as church during Byzance ruling when Christianity was considered as an underground practice (Golani,1986).

The chronology of utilizing the earth sheltered spaces in this region begins with Hittite, Romans, Greek, Byzance and ends up with Turks in a thousands of years duration. The Byzance established a vast network of underground space to serve as monasteries and churches with a touch of art. The majority

of the developed cities and rural areas belong to Hittite's from middle of the second millennium to the middle of the first millennium B.C. The number of these dwellings in this region is numerous. Nevsehir and Kayseri can be considered as the two main underground cities in this area (Fig.8) (Golani and Ojima,1996).

The earth sheltered rocky dwelling complex in Grome valley, Cappadocia, Turkey is one of the first residential areas in the region. The conic spindle shaped projection sand hills make up one of the most astonishing natural landscapes in Turkey. Due to grate diameter and thickness of the rocky features light provision for lower floors is very hard. Most of the openings are for light provision for the upper levels (Fig.9).

Derinkuyu is one of the 30 cities of the region with a total of 1,500m² underground built areas in 8 floors while only one fourth of it is discovered. There is a theory stating that these types of cities were used for defense purposes where the citizens could survive and come out when they felt safe. Every corridor was equipped with a stone-door, easy to open from inside and hard from outside. Among such cities Kaymalki, Ozkonak, Avanos, Kayseri, Asarkaya, Agirnas and Doganli are notable (Golani and Ojima,1996).

The Earth Sheltered Complexes in Mesa Verde

Another ancient specimen of rocky earth sheltered dwelling is found in Mesa Verde near Cortez, Colorado. This area consists of Red-Indian's habitat famous for its numerous rocky shelters established in not so deep caves and Rocky hanging-terraces along the valley straits. The front wall is made of domestic stones and soil as mortar that connects to the main body. The internal structure of these structures in general is made of hard sandy rocks connected to one another by bricks (Fig .10),



Fig.5: Roman villa in Bulla Regia, Tunisia. (Source:<http://www.flickr.com/photos/58356728@N07/5993147276>)



Fig.6: Rocky structure Tunisia. (Source:<http://members.virtualtourist.com/m/p/m/139.2da/>)



Fig.7: Bellow ground dwelling, Matmata, Tunisia. (Source:<http://swedal.hubpages.com/hub/Matmata-Underground-Town-In-Tunisia>)



Fig.8: Underground city Nevsehir, Cappadocia, Turkey. (Source: <http://dinamars.hubpage.com/hub/Trip-to-Cappadocia-Part-3>)

(Mesa Verde national park-wikipedia, 2010). The greatest complex here covers an area of 40 hectares with 1,200 rooms, 135 prayer houses and 19 towers. Since in certain sections a tall vertical cavity of 15m is found, some residential structures have 5 stories which are connected to one another by ladders installed on the facade (MofidiShemirani et al., 2012).

Ancient Earth Sheltered Structure Complexes in Iran Maymand Village, Rocky Earth Shelter

This village is located at 36km North-East of Babak city, Kerman province, Iran (<http://www.keacheh.blogfa.com/cat-8.aspx>). All structures here were excavated during centuries and look like a series of caves. The only way in and out of these structures is the one pass way that serves as light and ventilation channel as well. These structures are stable because they are all built on integrated and covered with natural rocky ceiling, providing residence for natives for centuries (Ghobadian, 2009). The Italian archeologists estimate the age of Maymand civilizations as 6 to 12 millenniums due to the studies and test conducted and ran on stone carvings found in the region (Izadpanah, 2003). Some researchers are of the opinion that the initial core inhabitants of Maymand must have lived in eras when Iranians followed Mithraism and worshiped mountains as sacred objects.

The earth sheltered complexes here are arranged in three layers at both sides of the North-South valley (Fig.11). These complexes are connected to interior up right to topographical layers named "Kicheh". The native order for naming the topographic layers is as follows: "Kashkor". The sequential pattern of reaching the leaving quarters are "Kicheh", "Veranda" and "Room". The rooms in these quarters have carved spaces in the wall to put torch/ lamp and other stuff on them. The

room height in these complexes varies from 1.9-2.1m.

The Underground City of Oii in AranBidgol

The underground city Oii is a district of AranBidgol city, 8km North of Kashan Isfahan province, Iran. This city is one of the most unique underground cities in the world with pre Islamic history. It was discovered when an excavation for housing project was going on in Nushabad city. The city was used as a shelter from invaders' attacks. It is built in 3 stories were possible with a total of a few thousand m² area under today Nushabad city (<http://www.govahiname.ir/>. 27.7.2012). The first floor is at 3m, the second is at 8-9m and the third is at 16-18m. below ground. The compact and yet vast structure's internal space includes networks of branched corridors, rooms, dark space are the triad features of this city (Fig. 12) (Mansuri and Chavoshnejad, 2011). The entries to these shelters are located at points in the city center like the marketplace, water storage, mosques and places that were crowded for rapid move to safety in case invaders attacked. The entries were closed in a specific manner and prevented intruders' entrance. Small rooms are covered along the corridors as temporary stations. The resident laid out procedures for safety and comfort during their temporary stay in these shelters (<http://www.govahiname.ir/> 27.7.2012).

The Rocky Earth Shelter Village of Kandovan

Kandovan is a rural area, 50km from Tabriz at south-west. The existence of residential structures among the conic rocky projections with a maximum height of 40m in four stories identifies this ancient area. The villagers here have built houses, barns and workshops (Shaterin, 2009). Even though some archeologists believed that this area belongs to pre Islamic



Fig.9: The earth sheltered rocky dwelling complex in Grome valley, Cappadocia, Turkey. (Source:<http://www.flickr.com/photos/jeffreydegrijs/3834979036/sizes/o/in/photostream>)



Fig.10: Mesa Verde rocky dwelling, Colorado, U.S.A. (Source: http://durangoreservations.org/mesa_verde)



Fig.11: Maymand rocky village, Kerman, Iran.



Fig.12: Oii underground city. AranBidgol, Isfahan. (Source <http://www.jamejamonline.ir/newstext.aspx?newsnum=100843420256>)

era, the initial ancient residents here were from a village named Hileware, 2km west of Kandovan, who had fled the Mongols attacks in 7th century A.H to the fields opposite what makes Kandvan now. During time they gradually excavated the conic rocky projections and established what exists now. This village due to its specific architectural texture is registered in the National Heritage Society, Iran. Due to the volcanic reactions of Sahand Mountain this beautiful landscape has evolved in one of the best climatic zones of Iran. The rough shaped volcanic mounds have been shaved and shaped through wind, snow rain and climatic factors during thousands of years.

The villages removed the rocks and built somewhat small rooms with 2m height (Ghobadian, 2009). One dwelling may be two-three stories. These natural features are fit to cold climates since the wall width varies from 2-3m, a good insulation as an energy saving factor. Accordingly, very low temperature fluctuation inside the structure, in a sense, during winter the room temperature is higher than outside temperature and the opposite is true for summer¹ (Fig .13).

Access to higher floors of these conic structures from outside and is provided by staircases carved in the intact body of the structure. They used to ground floor as storage and the next floors for residence. In certain occasions the fourth floor has served as storage house. Due to the big diameter and the thickness of the around rocky walls providing light for lower floors is hard so sunlight entered the structure in the higher floors (<http://hamshahrionline.ir/>).

The Underground City, Samen

This city is located in Hamedn province and was revealed during an archeological investigation. The city is hand carved on a rocky foundation. It pertains to Arsacid/ Partian area.



Fig.13: Kandovan rocky village, Tabriz, Iran.
(Source:<http://www.khorasannews.com/>)

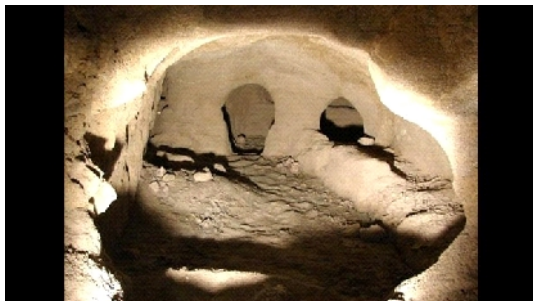


Fig.14: Samen underground city, Hamedan.
(Source :<http://www.hamshahrionline.ir/x/>)

Some of the space here has served as Mithraism worship centers and burial grounds. The evidence indicates that Mithraism was practical in secrecy. About 25 rooms have been exposed where many intact skeletons in squatting positions with some offerings next to them are found.

Based on the archeological studies conducted on this underground city, it covers 3 hectares. Due to high humidity in the vicinity some of the city is not revealed yet. It is assumed that this portion of the underground city has been exposed to the sewage of the city built on it (Fig .14). The city is found at 3-6m depth with corridors, channels and rooms built in different areas. These channels have interesting architectural patterns and specific applicability (<http://www.hamshahrionline.ir/>).

The Underground City, Khouin

This city of Khouin in located in Zanjan province. Dejmaneh or the underground city of Khouin is on Provincial Heritage Society's reconstruction program with an attributed budget. Obviously the numerous open and closed pathways in different floors of this complex should be investigated. The gigantic door made of stone that seems to divide the city into two main and secondary sections has carved inscriptions on it which should be studied deduced by the experts (Fig.15) (<http://www.asriran.com/>).

RESULTS AND DISCUSSION

The Types, Genotypes and Phenotypes of Earth Sheltered Structures

In general type is defined based on its physical elements. If an object contains features that identify a group of things the object is named under that type. The expression genotype and phenotype constitute the basic conceptions of the syntax "space" in typology. The genotype in architecture is the internal data hidden in architectural space and is considered as the appearance of the phenotype or the physical pattern of the given object. It is worth mentioning that in case of change in phenotype the genotype remains constant. The context of genotype reveals the natural structure, the elements' interconnection and the internal pattern of the physical objects which is changeable due to their forms. The phenotype, which is the physical type, is able to vary in shapes; while many shapes may have only one genotype. Consequently, no spatial and time restriction could be assigned to the number of genotypes; therefore, it is possible to see one type of genotype in one or more structures in two different spaces and in different time zones (Memarian, 2006). Connection with or establishing a bond with earth is considered as the earth-sheltered structure genotype. The phenotype of these structures could be different i.e. they might be established under the ground level, in the rocky



Fig.15: Khouin underground city, Zanjan.
(Source <http://www.asriran.com/>)

slopes of the mountains or next to another building as a complementary for different utilities (Khodabakhshian, 2012).

The Earth Sheltered Structures' Types in Iran

These types vary in Iran in their physical sense that includes a subsidiary of earth- architecture as complementary or semi underground structures. Therefore earth-architecture is a genotype of earth-sheltered architecture. The focus of this study is on the earth-sheltered dwelling structures in complete connection with earth, not the complementary connection with a part of underground structures. Accordingly the complementary non-residential structures are not discussed in this study. Here, the earth- architecture that includes the earth-sheltered structures is analyzed. The main issue of discussion here in accordance with the defined criteria in architecture with respect to residential structures involves the two types of underground and rocky earth-sheltered architecture in Iran. The underground type indicates that these kinds of cities are built for weather and invader protection, the samples of which are presented. The rocky type consists of two continues and discontinues sub-categories, the samples of which are presented. The second category includes complementary elements in a sense that it is directly connected to an existing residential, service, cultural, religious structure. The Aghabozorg mansion-mosque in Kashan, Isfahan province, has a very big basement with a garden-pot in the center. Such structures in one or two floors are very common in non-coastal regions of Iran. Another type in this sub-category is the structures that are built semi-underground model like: the water storage, bathhouse and ice-storages. In these structures the half section below ground acts as the naturally insulated space (Khodabakhshian and Mofidi, 2012).

CONCLUSION

The earth- architecture as the genotype of earth-sheltered structures includes the three earth-mound, rocky and underground earth shelter phenotypes. The first, as the innovative type is established in plateaus. This type is common in the USA, Greece and England for energy saving and is not discovered in Iran so far. The rocky-sheltered phenotype whether ancient or historic are of two continues and discontinuous types which are common in Iran, China and Turkey. The underground phenotypes in Iran appear as underground cities. Although there are complementary underground spaces connected to the ground level structures the full underground residential earth sheltered structures are not found in Iran so far, while verity of this type is spread worldwide. If a bellow ground earth-shelter with central court yard is called as "Open", underground cities are called as "Closed". In general, the various types of earth- sheltered structures in Iran could be continued and discontinued rocky and closed underground types. Thus, Maymand is a specific type in the world that can be categorized as the sub-category of rocky and underground earth-sheltered structure where the Kiches function as the central yard, a type that is not available in Iran in single model which is named Combined Continues Rocky open Underground by this author.

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