The Conservation and Development Research of loess Cave

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Abstract. As a form of traditional houses and folk cultural buildings, cave dwelling has been a long history of several thousand years in Qingyang. making use of local geographical environment to the greatest extent, it is very simple to construct the cave dwelling buildings. It is also cool in summer and warm in winter. However, with the rapid development of urbanization in Qingyang, monotony of concrete buildings gradually replaced the cave dwelling in recent years, it is slowly declining. Therefore, it is important to inherit, research and expand the traditional houses and folk cultural buildings. The dissertation attempts to study the development situation and problems faced by the cave architecture and propose the solutions to protect and development cave architecture.

1. Introduction

The cave-house in the Loess Plateau is a traditional form of Chinese residence that lasted for thousands of years. It has condensed the wisdom of the people and the cultural connotation of traditional architecture for thousands of years. The Loess cave-house is derived from natural and assimilated into natural, and has the characteristics of local materials, local conditions, low cost, warm winter and cool summer, strong renewability, etc. It is a typical green building, which reflects ecological principles in many aspects. China’s cave-house dwellings can be divided into six districts, the cave-house area in Shaanxi, the cave-house area in mid south of Shanxi, the cave-house area in the west of Henan, the cave-house area in Hebei, the cave-house area in Ningxia, and the cave-house area in the east of Gansu \cite{1}. Qingyang cave-house dwelling is the main part of the east Gansu cave-house area. According to the terrain and construction form, it can be divided into cliff-type cave-house dwellings, sinking cave-house dwellings and free-standing cave-house dwellings. Cliff-type cave-house dwelling is the most common form of cave-house dwelling. It is also the focus of this paper. It mainly uses raw materials to reflect the main qualities pursued by human settlements such as energy conservation, ecological environment protection and inheritance of local culture.

2. Overview of Qingyang Cave-house Development

2.1 Cave-house history

The cave-houses in Qingyang City are widely distributed. In ancient times, they were known as “Wankong Cave”. The history of the cave-house in Qingyang can be traced back to China's 5,000-year history of civilization. Due to the unique advantages of the Loess Plateau, the intelligent Qingyang people created the most ancient cave dwelling cultural product, the cave-house. With the improvement...
of the primitive people's natural ability to transform, the original cave-house dwellings were gradually inherited and transformed. Until now, the sites unearthed in a few places in Qingyang still have the characteristics of 'burrowing'. In the Yangwa Yangshao Cultural Relics Site in Ning County, Qingyang City, a building site similar to the cave-house dwelling style was discovered. It has been around for about 5,000 years, which is the earliest cave-house dwelling found in the east of Gansu Cave-house.[2]. In addition, there are Miaozuiping Site in Ning County, Ning County Dianzigou Site, Ning County Dongzhuang Site, and Xifeng Xiansheng Liucheng Site. They all have their own characteristics, but the residential forms are different.

2.2 Cave-house development type

The Qingyang cave-house dwellings can be divided into three types, which are mainly divided by different terrains and different building materials.

(1) The cliff-type cave-house dwelling (also called the mountain cave-house) is the most common form of cave-house house in Qingyang. Because of its reliable terrain, it can be along the gully and along the plateau edge. It has the characteristics of adapting measures to local conditions and simple construction. The layout of the cliff-style cave-house dwellings mainly consists of three sides on the cliff, two on the cliff and one on the cliff. The cliff face (also known as the Zhuang face) of the cliff-style cave-house is generally about 10m high and 17m to 23m long. The three-hole or five-hole cave-house dwelling is excavated in the face of the cave-house. It is called "One Primary Two Subsidiary" or "One Primary Four Subsidiary" [3]. On the side, depending on the actual situation, some cave-houses for storing grain or for use in fire room (kitchen) can be properly dug. The entire cliff-style cave-house-dwelling courtyard is mainly based on axis symmetry, and the layout pursues balance and regularity. The cave-house dwelling is a vault-type cross-hole that is excavated inward in the face of Zhuangzi. The scale is “the width of the cave-house is one foot, the depth of the cave-house is two feet, the height of the cave-house is one foot and one foot, and the cave-house leg is nine feet” [4]. The horizontal surface of the cave-house is rectangular, which wide 3~4m and deep 5~9m.

(2) Sinking cave-house dwellings (also known as pit cave-house or flat cave-house), mainly built in areas without cliff faces or flat terrain, people choose sites mainly in Waterlogging pool topography or good surroundings. Before excavating the cave-house, they will dig a square pit to form a sinking square yard and a wall surrounded by four sides. Then they will dig the four walls and select the main cave-house cliff face, usually digging a three-hole cave-house. Generally, the opposite side of the main cave-house will be used to construct the passage of the Zhuangyuan to the outside, and the other two sides will dig the same number of cave-houses. The waterproofing and drainage of the sinking cave-house is the key factor. Generally, the soil is built at the appropriate position on the top of the cave-house or the brick is built as a low barrier for the water retaining wall. The water in the pit is accumulated by digging a hole in the courtyard. It is used for livestock drinking and laundry.
Fig. 2 Sunken cave-house dwellings

(3) Freestanding cave-house dwellings (also known as hoop cave-house). It is built in the courtyard of the flat or the mountain. It is not built by excavation, instead, the adobe or brick is used as the wall and the vault to form a cave-house structure, which is covered with soil. Therefore, this kind of cave-house dwelling is also called the casingsoil cave-house dwelling or the hoop cave-house. The roof of the free-standing cave-house can be made into a flat roof or a sloping roof after being covered with soil. It can also be covered with one or more layers to form a multi-storey cave-house building. The selection of building materials for cave-house dwellings can be divided into adobe, brick and stone. The outer surface of the adobe cave-house can be covered with a layer of brick or ceramic tile to make it look beautiful.

Fig. 3 Adobe Freestanding Cave-house Image and Brick Freestanding Cave-house Image

2.3 Characteristics of loess cave-house dwellings

The idea of the independent cave-house dwelling originates from the traditional loess cave-house dwelling, which combines modern building methods and materials. It is a derivative building of the loess cave-house dwelling, and its development is still immature. For the characteristics of loess cave-house dwellings, this paper mainly analyzes the traditional loess cave-house dwellings. The main difference between cliff-type cave-house dwellings and sinking cave-house dwellings are that the location and shape are different. The construction methods are based on the 'subtractive method', their own features also have similarities.

(1) Simple and unadorned. The loess layer in Qingyang City is thicker and the annual average precipitation is less, which creates natural conditions for the formation of cave-house dwellings. The cave-house dwelling is also relatively simple. The width of the cave-house dwelling is generally 3 to 4 m, the height is 3 to 4 m, the depth is 5 to 9 m, and the width of the cave-house leg is about 3 m. The cave-house pattern and decoration are also relatively simple. The facade is reinforced by smearing fine mud or clay bricks, stone, etc., which can mainly prevent rainwater from scouring.

(2) Natural green buildings. The Qingyang cave-house dwelling building is based on the local superior loess resources. It is a natural earth building, energy-saving building and ecological building. To this end, this paper is summarized as a green building. First of all, the cave-house dwelling is built
in or on the loess. The process of excavating the cave-house dwelling is only a process of borrowing and moving. The site selection of the cave-house dwelling can also be adapted to local conditions. The craftsmen can excavate and repair to a certain extent according to different terrains. It can be a complete courtyard, it can be described as a complete raw soil building; secondly, because the loess has good heat insulation and heat storage function, the summer temperature in the cave-house is not too high, and the temperature in winter is not too low, even outdoors temperature at -20 °C, the indoor temperature can generally be maintained at around 15 °C [5], this winter warm, summer heat-insulation is a prerequisite for energy-efficient buildings; and no matter it is the choice of building materials, or the life equipment, The use of cave-house dwellings has the characteristics of low cost and original ecology.

(3) Rich cultural connotations. Qingyang is an important source of agricultural civilization in China, and its farming folk culture is rich. As the main architectural form of the Qingyang people's generations, the cave-houses witnessed the hard work of the Qingyang people for generations, and also carried the development mission of many folk cultures. Huan County, Qingyang City is the hometown of shadow puppets in China. It was originally performed in cave-houses at the beginning of its birth. Paper-cutting was also used as an ornament on the walls and walls of cave-houses. There are also the creation and development of folk art such as embroidery and yangko, which are influenced by the cave-house culture.

3. Development Status and Problems of Loess Cave-houses

In recent years, with the acceleration of the urbanization process and the improvement of people's living standards, the traditional industrial structure and the concept of living and living have also changed. The phenomenon of “abandoning cave-house building houses” and “abandoning land to change jobs” is prevalent. The development of Qingyang loess cave-house dwellings has faced many aspects of crisis, and cave-house dwellings are also coming to an end. The main reasons for this phenomenon are as following.

(1) The impact of the rapid development of urbanization and the transformation of residents' ideological concepts. In 2017, the permanent population of urban areas in China reached 813 million, and the level of urbanization was 58.52% [6]. The process of urbanization development is also the process of rural residents moving to towns, which makes the original cave-house dwellings gradually abandoned. At the same time, due to the influence of urbanization and modern architectural thoughts, people's living standards have improved. People think that cave-house dwellings are the symbol of poor and backward, while the building is an advanced and civilized symbol, so the residents who originally lived in the cave-house dwelling began to build houses, and the phenomenon of “abandoning cave-house and building houses” appeared.

(2) The illusion of the backward environment of the cave-house living environment. The existing cave-house dwellings in Qingyang are mostly built for a long time. The site selection is mostly built along the gully beams, and it has the characteristics of near-ground and scattered. Due to the limited radiation capacity of the city, the infrastructure construction of the village is still not perfect, and the residents of the cave-house dwellers are generally difficult to travel. The difficulty of shopping, the difficulty of seeing a doctor, the difficulty of going to school, the lack of leisure and entertainment activities, and the illusion caused by backward infrastructure made people gradually give up the cave-house dwellings.

(3) The shortcomings of the cave-house itself. The Qingyang cave-house dwelling is the simplest decoration in the six cave-house areas. Although it is adapted to local conditions and taken locally, it saves costs, but it is too simple and rough. At the same time, due to frequent natural disasters such as earthquakes, landslides and mudslides in recent years, people living in cave-house dwellers are worried about the safety of cave-house dwellings. The damage forms of cave-house dwellings are mostly local collapse, overall collapse and cracks. The collapse is mainly caused by the collapsibility and seismicity of the loess. The collapsibility is the phenomenon that the overburden of the cave-house is significantly deformed by the structural damage of the soil after the water immersion under the
combination of the self-weight stress and the additional stress. Sex is the additional subsidence of loess under earthquake or the phenomenon of vibration collapsing caused by earthquake; crack is divided into structural crack and structural crack, and structural crack is related to loess joint. Because of the existence of pores in loess, pores generally contain pore water. The effects of freezing and thawing, rainfall, and weathering of the paleo-soil layer may cause cracks in the soil of the cave-house. Generally, the phenomenon of the shady surface is serious. The structural crack is a deep crack caused by the fracture or misalignment of the arch ring.

(4) The academic research is weak and cave-house construction technology lags behind. At present, the academic research on cave-house dwellings mainly focuses on culture, living environment, and causes of disasters. Most of the researches are theoretical analysis of the status quo and lack of research on practical guidance. The current state of the cave-house construction technology is mainly the self-exploration of the villagers and the income of the older generation. Due to the influence of the knowledge level, it is difficult for them to innovate the cave-house building technology, and the cave-house construction technology lags behind. This kind of theoretical research and practice can not be integrated, and the status quo of "all the way" makes the cave-house building difficult to be used in the practice of modern construction, and can not be innovative and inherited.

(5) The policy and institutional bias. The government is the helm of the development direction of urban and rural construction and the leader of the development of building technology. In most places in Qingyang City, most government officials have prejudice against cave-house dwellings and believe that cave-house dwellings are a symbol of oldness and backwardness. In the construction of new countryside and beautiful rural construction, there is no mention of the protection of cave-house dwellings and the use of cave-house dwellings. It is a modern building with a row of rows; in the construction of towns, in order to pursue the floor area ratio and the so-called 'modernization' to abandon the cave-house dwellings, there is a phenomenon of urban construction in the town construction. In addition, for the cave-house dwelling construction, the state has not issued relevant construction guidance and index specifications, which makes the cave-house dwelling gradually withdraw from the perspective of people's attention.

4. Countermeasures for the protection and development of loess cave-house dwellings
(1) Improve the safety of cave-houses.

The study on the hazards of loess cave-houses is mainly affected by its own collapsibility and seismic subsidence. According to the experience of the loess cave-house dwellings in the earthquake, the seismic performance of the Loess cave-house dwellings is better than that of mixed load-bearing houses and earth-rock walls. Even better than wooden truss houses and brick-concrete structures [7], therefore, to study the engineering properties of loess, in order to ensure the safety of the cave-house building, the following aspects should be noted. (1) The location of the cave-house dwelling should be investigated for geological and geomorphological conditions. It is not suitable for site selection in places with vertical joints and loose soil to avoid construction on the Loess cliff where severe earthquakes may occur. (2) The site should be on a stable cliff slope. The thickness of the covering soil is about 5.0m, and should not be located in the high-steep terrain. (3) The water-proof and ventilation work of the cave-house should be done well. The cave-house dwelling on the shady slope is more susceptible to damage due to factors such as freezing and thawing. The facing of the sun should be done. The design of the doors and windows should take into account the absorption of light as much as possible. At the same time, the drainage and waterproof treatment of the cave-house roof and the cave-house side soil should be carried out. (4) The cave-house dwelling mainly occurs in the cave-house face and the hole, and there are also cracks at the top of the cave-house, reinforcement measures should be taken at these parts.

(2) Improve the cave-house area planning and cave-house construction technology work.

The government is the guide for urban and rural development and has a promoting role in urban and rural construction. In particular, the development of village layout planning and beautiful rural planning in recent years has strongly promoted the pace of urban and rural construction in the region,
but it is regrettable. The existing plans are all modern housing construction plans, and there is no protection and development of cave-house architecture. Due to the complex topography of Qingyang City, there are many topographical features such as plateau, gully, Liangzhu, river valley, Pingchuan, slope, etc. The existing natural cave-house dwellings are mainly divided into four types of distribution, namely point distribution, current distribution, and layering. Distribution and mixed distribution. The urban and rural construction planning should include the protection and construction of cave-house dwellings. For different terrains, different architectural forms, especially valleys and slopes, and cave-house dwellings need only be “reduced”. Whether it is based on cost of capital, land cost or ecological cost, it is the best choice. In addition, in order to improve the technical work of cave-house dwelling construction, the government department should be the main organizer and core force of this work. The scholars of relevant research can transport the technical methods of modern architecture to the cave-house dwellings and combine the relevant experience of the cave-house dwellings. Summarize and compile relevant technical guidelines and cave-house building construction specifications, so that the cave-house dwelling theory is well documented and truly integrated into the modern family.

(3) Create a modern and livable cave-house environment.

The existing cave-house dwellings in Qingyang are mainly distributed in rural areas in mountainous areas. This is mainly due to the fact that the peasant dwellings need to be adjacent to the fields that are engaged in farming. The current urban and rural planning should be adjusted according to the distribution rules of rural settlements. Improve the infrastructure and landscaping work in the cave-house area.

First of all, we should speed up the improvement of the infrastructure construction of the cave-house area. The government should increase financial input and mainly implement water supply, power supply and access projects in the cave-house area. On this basis, according to the size of the population and the distribution characteristics of each cave-house area, a reasonable service scope is determined, and the construction of supporting facilities in the cave-house area, which is mainly composed by education and medical services, supplemented by entertainment and shopping, is improved.

Second, we must accelerate the construction of green energy projects and village capacity rectification in the cave-house area. Solar water heaters and wind power generation are the main directions for the use of green energy. Because the raw materials for biogas fermentation include human and animal waste, plant straw, organic waste, etc., it is also the most common green energy for rural development and use. While actively using green energy, we should also implement greening, purification and beautification of villages, implement rainwater harvesting and utilization, sewage treatment and discharge, and garbage recycling and utilization projects to achieve effective use and sustainable development of resources, and fundamentally improve the “dirty, chaotic, poor” impression of the cave-house area.

Thirdly, through the poster propaganda and technical guidance, the residents of the cave-house area will be guided to beautify the cave-house building. The cave-house courtyard is mainly beautified by the cultivation of gardens, vegetable gardens, and greening around; for the exterior of the cave-house, bricks and concrete can be used for masonry, and the cave-house surface can be simply decorated to achieve aesthetics and reinforcement. For the cave-house, the roof is mainly reinforced and decorated with steel reinforcement and ceiling. The walls can be beautified with wallpaper and brush paint. The floor can be cement hardened, paved, and laid. The doors and windows should be larger and have a good daylighting effect.

(4) Enrich the cave-house dwelling function and guide residents to participate in the protection and development of new cave-house residence mode.

Cave-houses are the most important part of people's living space, and their traditional functions are mainly for residential and grain storage. With the improvement of living standards, people also hope to have cultural, entertainment and other spiritual needs in addition to pursuing basic food, clothing and housing. Cave-house culture is an important part of Qingyang farming culture and the most
natural and ecological building. This makes the cave-house building have the charm of more functions. First of all, we should enrich the function of the cave-house area, introduce public utilities into the cave-house dwelling, develop cave-house dwellings, cave-house schools, cave-house shops, etc., and develop cave-house dwellings so that residents in the cave-house can truly experience the advantages of using cave-house dwellings. Secondly, the development of cave-house tourism, combined with paper-cutting, shadow-shadowing, pipa and other folk culture and relying on the red tourism foundation of Qingyang City, to build a cave-house hotel, cave-house museum, etc., so that foreign tourists can enter the cave-house building and experience the cave-house culture. At the same time, it is also possible to develop a cave-house leisure resort, combined with the leisure agriculture industry, so that visitors to this holiday can get close to nature and experience the process of field farming.

5. Conclusion
The Qingyang cave-houses on the Loess Plateau complement the Qingyang farming culture and are the product of the development of the millennium and the wisdom of the people. This paper discusses the problems existing in the development of traditional cave-house architecture, and proposes countermeasures and suggestions for protection and development. However, the development of Loess cave-houses should not be ceased. The freestanding cave-house dwelling is a derivative form of Loess cave-house dwelling. Although its development is still in its infancy, compared with the traditional Loess cave-house dwellings, it is only “Similar in appearance, not intrinsic”, but it also provides the research thought for the loess cave dwelling to realize the long-term development. Therefore, to realize the modern development of loess cave-house dwellings, let the cave-house dwellings out of the countryside and integrate into the urban construction, and guide the development of urban and rural construction characterized by Qingyang is also the focus of future cave-house dwelling construction research.

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