Study on Traditional Model of Rainwater Harvesting and Utilization in Guanzhong Area of Shaanxi Province

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Abstract. The research mainly studies the types of traditional rainwater harvesting and utilization patterns in Guanzhong area of Shaanxi Province. From the point of view of increasing efficiency and saving resources, study the types and mechanism of public rainwater harvesting facilities in traditional rural settlements in Guanzhong area and the patterns of rainwater harvesting and utilization in traditional residential buildings respectively can definitely increase efficiency of water in semiarid regions.The aim is to summarize the intrinsic value and significance of traditional rainwater harvesting and utilization.On the part of low impact development design, study of traditional rainwater harvesting patterns could build a green ecological design system with more efficient way and low energy consumption.The traditional rainwater harvesting and utilization mode is not only shows the national wisdom of Guanzhong people, but also the embodiment of the life philosophy of its green ecological human settlement.

Keywords: Rainwater harvesting, rainwater utilization, traditional ways, human settlement.

1. Introduction

Recent years, the deterioration of the climate has led to easily water-logging in summer and drought problem in winter because of lack of rain at the most part of Guanzhong area. How to make rainwater collection and utilization as a supplement to daily water resources has become a problem that has been concerned and studied continuously in recent years. Meanwhile, rammed and wood architecture of traditional residential has been declined since 90's, some were torn down and changed to brick-concrete structures, some have been abandoned due to broken a lot. It's not just the change of the residential environment, but also leads to the abandonment of traditional culture and native intellectual connotations. Residential environment construction in Guanzhong area has been attached to nature since ancient times, to create a harmonious and ecological human settlement environment. Clarify the types of collection and utilization patterns of their traditional rainwater use playing an important role in the research of regional green building and low impact development planning and design in the future.

2. Rainwater Harvesting and Utilization of Traditional Buildings in Guanzhong

2.1 Rainwater Harvesting and Utilization of Building Yard.

1)Heyuan Building Courtyard

The traditional architectural forms in Guanzhong area are mainly represented by courtyard, and contained within "Zhengfang" (master residence of wing) which is always located in the middle of yard, and the "Xiafang" (chamber or wing) on both sides of the yard, the "Mengfang" (reverse-facing rooms)is nearby the street, also called "Daozuofang". There main different functional buildings enclose a space which is called as "courtyard". Unlike Beijing Siheyuan, the courtyard of Guanzhong area is more rustic and simple which perfectly illustrates of Guanzhong people's bold and rustic personality characteristics. The courtyard is generally built with rammed base, paved with bricks on the surface, as a basis of courtyard construction. The ground floor of the courtyard is reserved for drainage holes at the lowest, while the drainage channel is pre-buried in the rammed base, connected to the drainage hole, and the rainwater is collected and discharged into the back-

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yard wells when the rainy season comes. Not only to ensure that the entire courtyard from the visual beauty and integrity, but also to collect rainwater and for reuse. To achieve functional and ornamental in sense of harmony. Throughout the courtyard, “Zhengfang” is generally used as a living room, and as the the most important functional building located in a higher terrain, “Mengfang” is always located in a lowest terrain of courtyard. Therefore, in the heavy rainfall, the excessive rainwater to the outside of the courtyard through the brick drainage channel, to avoid gathering in the courtyard, with the terrain drop naturally.(Fig.1)

Most courtyards have wells in the backyards and connect with drainage ditches which are paved under the rammed base. Rainwater is filtered by sedimentation as a result for reuse for daily life or agricultural irrigation. When the rainy season comes, water tanks would be set up in the courtyard as rainwater containers, remove impurities by settlement and obtain more purer water for domestic use and also plays a role of landscape design in courtyard with plants（pontederia cordata、wanren and lotus)and fishes to make a pleasant andscape. The layout of the courtyard building which is complies with the terrain in ingenious way in Guanzhong area, the rainwater is collected and utilized without excessive artificial construction. The "gathering" of water in the courtyard is also a wealth of gathering in traditional culture in china.

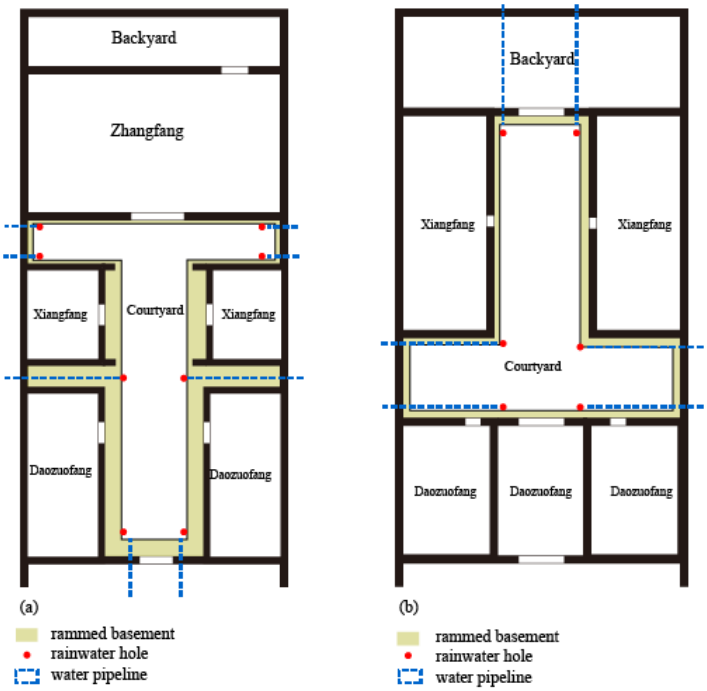

Fig. 1 Layout of traditional residential buildings of Heyuan in Guanzhong

Fig. 2 Sunken Yaodong of Guanzhong area

2)Yaodong Building Courtyard

In the middle and north of Guanzhong area, as the whole terrain is rising from southeast to northwest, and the thickness of loess layer is increasing, the type of Yaodong building is formed according to local conditions. The architectural layout makes full use of local landform and there are three main forms of formation. One is relying on cliffs, digging caves, named as Cliffside Yaodong, the other is digging pits in low-lying places to form sunken courtyard, called Sunken Yaodong, (Fig.2) the last one is called Hoop Yaodong which is built on the ground to form a arches-style independent building. All three types of Yaodong are the embodiment of the wisdom of adapting to nature of local people. The interior space is warm in winter and cool in summer, adapting to the seasonal changes in Guanzhong area. A low wall or low bar on the top wall outside the cave yard, used to block part of the rain from flowing into the yard. Utilizing topographic features to build Yaodong to the full extend, connecting with external roads, draining off water through blind ditch or pipe. While the Sunken Yaodong is due to its special geographical conditions, the water could not drain away outside the house.As a result, the wells are often dug at the lowest terrain in the courtyard, as a collection of rainwater from the ground. At the same time,rainwater with soil purification and Infiltration, and some of it could be groundwater to be supplied. Rainwater is introduced into the water cellar through ditches for collection might as well, settlement, filtration and reuse.

2.2 Rainwater Collection and Utilization of Roof.

1)Rainwater Collection and Utilization of Heyuan Building Roof

The traditional architecture in Guanzhong area are mainly Heyuan buildings with courtyard, and the building roof is mostly single-slope or double. Make sure to keep 70% of the area of the upper tile as a coverage one to the lower one while laying tiles on the roof for ensuring its thermal performance. Two or three tile buckles of gable wall to enhance waterproof performance at the intersection of roof. Simple form of roof laying to the main tile with dense arrangement becomes a main characteristic of the roof of traditional residential buildings in Guanzhong area. When the rainy season arrives, the rain runs down the tile slope, falls into the courtyard, passes through the drain holes lean on rammed base, flows into the drainage pipe under the rammed base, finally ends up in the backyard wells or runs off outside the house. The width of the position of the general eaves rain, in order not to fall into the rammed base for the best, to ensure that the rainwater can be quickly discharged through drainage ditch. The design of slope roof not only controls the direction and flow trajectory of rainwater, but also makes full use of rainwater resources in combination with the smart design of drainage system in the ground courtyard. A few rich families generally set the Chinese traditional Dishui(drip edge) at the end of the eaves, so that rainwater can be quickly discharged.

2)Rainwater Collection and Utilization of Yaodong Building Roof

Sunken Yaodong formation is to dig a square well on the ground, the pit of the four sides to be flattened, people on the ground can not directly see the inside of the cave house. Rainwater collection of this type of Yaodong mainly depends on well in the courtyard, make sure the infiltration of rainwater to the underground and as a part of groundwater replenishment. Cliffside Yaodong depends on the mountain or cliff, which is embedded in the mountains and can be regarded as a part of mountain. Mainly excavate the cave in the same direction, with horizontal arrangement or vertical arrangement. The vertically arranged cave houses roof are mostly hillsides or ground of upper caves , and are used in neighborhoods. Hoop Yaodong is a kind of independent building which is built on flat ground using arches form, and roof is similar to the slope roof form. Generally in the caves on the surface of the soil to do drains, so that the rain down the drain to the sides, or the upper part of the cave sloping back, the formation of the front low and high, so that rainwater into the back of the drain.

3. Traditional Project of Rainwater Harvesting and Utilization in Guanzhong area

3.1 Road Rainwater Harvesting.

One of the characteristics of the traditional residential architecture in Guanzhong is that the drainage is integrated into the building, and no specific rainwater facilities are set up for the collection or discharge of rainwater. In the early stage of construction, residential buildings fully consider the problem of rainwater collection and discharge, and the length and height of each eaves inside the courtyard are established, not only adhering to the feudal hierarchy, but also taking full account of the problems of rainwater and take minimal manual intervention on environment. In traditional construction, on the basis of primitive roads to carry on the terrain slope improvement, achieves the successful drainage.The general outdoor drainage slope is controlled at 1%-3%. At the same time, some residential building along the building dig drains, emit excessive rainwater to the outdoor roads.

3.2 Laochi.

Laochi means waterlogged pool, as the public space in the construction of traditional rural settlement in Guanzhong area, and that is the core region of collecting, intercepting and recycling rainwater in the whole village. From the general point of view of the overall rural settlement, the construction fo Laochi adapts to the natural terrain, located in the village relatively low area, in the field or roadside, excavation of deep pits. The size and depth of the Laochi generally depends on the local topography and rainfall specific conditions. The area is generally between half an acre and an acre, the shape generally appears round or oval. The rain flows down the sloping road to the Laochi, passing through a two-stage or three-stage waterlogged pool, to solve the hidden danger of rural water-logging. Meanwhile, through a certain settlement, filtration, can be reused for crop irrigation, and domestic water etc.

4. Connotation of Traditional Rainwater Harvesting and Utilization Model

4.1 Design Connotation of Low Impact Development.

From the point of view of building monomer design of a small scale, some rainwater is introduced into the interior of the courtyard with roof slope and would be collected in the water storage tank, then utilized. The excessive one is excluded from ditches which buried under rammed basement to avoid water-logging in courtyard, and then gather around with wells outside the house. This is especially important in areas where rainwater is scarce or infrastructure is inadequate, and a small set of wells can carry a family of water for a week or even half a month. To the mesoscale rural settlement construction, choosing the lowest or much lower spot of village to establish Laochi(waterlogged ponds), in response to heavy rains, with natural slope of the road, flows into low-lying places with natural filtration, or into Laochi. From two prospects of small and medium scale, planning and design are both perfectly harmony with nature.By complying with terrain topography, the landscape of traditional local characteristics is built.

4.2 Green Ecological Living Concept of Human Settlements.

Villages continue to gather to form small groups, and then continue to expand, adapt to nature, and ultimately reach a stable form. From the formation of its natural geographical aggregation, the design of the natural devices collected by rainwater utilization in the settlement, to design of traditional houses, landscapes and buildings, to the rainwater components of architectural decoration details, is the embodiment of Guanzhong people's concept of harmonious life based on green ecological human settlements. Residential buildings of Courtyard are quite narrow, deep and narrow, as the name calls "Narrow Courtyard.” which advantage is to save land resources and make full use of an inch of land. The Yaodong building is backed by the cliff, or complying with terrain of the loess plateau, which all embody the rational use of the resources of nature. From the choice of residential buildings and the trend of the regional characteristics to the use of natural geographical terrain characteristics and the formation of the unique landscape of rural settlements, the settlement into the surrounding environment, in line with to collect and use rainwater, to create an artificial circulating ecological water system,(Fig.2) the formation of natural microclimate for environmental regulation,

will be in harmony with nature and green ecological and environmental protection of the concept of human settlements tightly integrated in daily life.

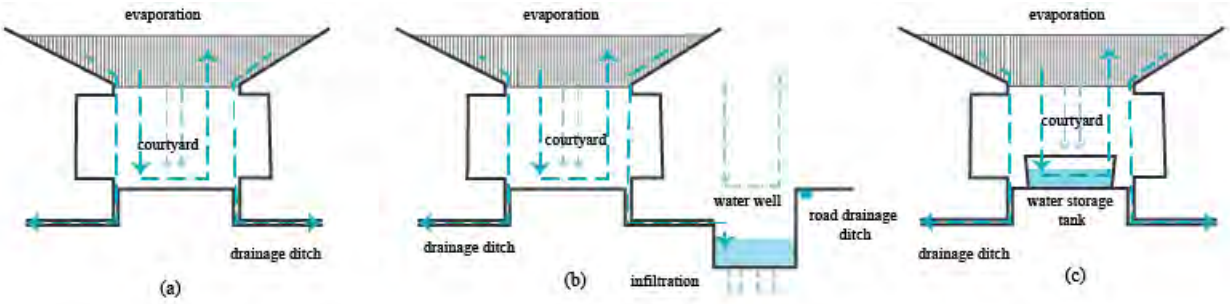

Fig. 3 Water circulation system of Heyuan building

4.3 The Embodiment of National Connotation and Wisdom.

Guanzhong area is located in the weihe river on the riverside floor, close to the water source, south of the Qinling mountain veins as a barrier, its location fully reflects the ancients in awe of nature, but also the wisdom and national connotation reflection of local people. The formation of a village, in line with its natural topography, choose the lowest place as the site of the Laochi, and with two to three stages of rainwater deposition, filtration, natural rainwater purification and then reuse with irrigation or to solve the problem of water difficulties in daily life. It also embodies the awe of resources obtained in nature of Guanzhong people."Water" in the traditional national cognition means of gathering wealth.Taking advantage of variety of structures or decorative components to guide the rain to fall into the courtyard, leaving rainwater "stay" in the courtyard, as a reflection of the prosperity of the family's good wishes. It is not only the result of man's use of nature, but the result of man's awe and humility towards nature. The building components of the Watong, Dishui, Goutou all have a strong local characteristics of the pattern with delicate carving. It shows the strong regional cultural characteristics of Guanzhong area, combines the language of architectural humanities with nature, and forms a harmonious humanistic landscape which can embody the integration of manpower and nature, and also can deeply embody the traditional national connotation of awe of nature of local people.

Acknowledgments

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