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Research on Traditional Rammed Earth Houses in Southern Zhejiang, China: Based on the Theory of Embeddedness

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***Abstract*—**Zhejiang's special geographical environment has created characteristic mountain dwellings with climate adaptability. Among them, the terrain of southern Zhejiang is dominated by mountainous and hilly landforms, and its traditional dwellings have distinctive characteristics. They are often adapted to local conditions and laid out in accordance with the mountains. In order to block the severe winter weather conditions, local traditional building materials such as rammed earth are mostly used. However, with the development of urbanization, traditional villages have undergone large-scale changes, gradually losing their original uniqueness. In order to solve this problem, this paper takes traditional villages around Baishanzu National Park in Zhejiang as an example and selects nine typical villages in Jingning County and Longquan, respectively. Based on field investigations, this paper extracts the environmental adaptability of local traditional rammed earth houses from the perspective of "geographical embeddedness". And then combined with case analysis, the paper discusses the translation and development of its traditional architectural methods in contemporary rammed earth buildings in southern Zhejiang.

***Keywords*—**Rammed earth building, lighting, ventilation, geographical embeddedness, modernization translation

I. Introduction of Embedding Theory

THE concept of embeddedness originated from social economics, emphasizing the dependence of the economy on other factors such as politics, culture, religion, etc. It was first proposed by Polanyi (1944) and applied to economic theoretical analysis [1]. Granovetter (1985) re-elaborated the theory, making it a bridge connecting economic sociology and organization theory [2]. Zukin and Dimaggio (1990) extended the concept of embeddedness and divided it into four types to further improve the theory [9]. Hagedoorn (2006) divided embeddedness into three levels from the perspective of organizational embeddedness: macro, medium and micro [3]. With the application and deepening of embeddedness in the management of economic sociology, embeddedness theory has also been introduced into fields such as human geography, politics and architecture.

Studies in China on embeddedness theory are mainly focused on economics, politics, tourism, architecture and other fields. Ning (2017) studied the protection of traditional villages from the perspective of geographical embeddedness and disembeddedness of traditional villages [4]. Lan (2018) studied the impact of institutions on community participation in tourism development from the perspective of institutional embeddedness [5]. Yi (2020) studied the influence mechanism of embeddedness on the sustainable economic development of ancient village tourism destinations [6]. Xi (2021) studied how to integrate culture into the design of grand Canal waterfront landscape from the perspective of cultural embeddedness [7].

In traditional villages, geographical conditions greatly affect the shape and form of local dwellings. Therefore, this paper studies the traditional construction wisdom of rammed earth dwellings in southern Zhejiang from the perspective of geographical embeddedness, and selects nine typical villages in the surrounding area of Baishanzu National Forest Park located in Jingning and Longquan (as shown in Fig. 1), extracting environmental adaptability techniques of local traditional rammed earth dwellings on the basis of field research, and analyzes the impact of geographical environment on the architectural pattern details and forms of local traditional rammed earth dwellings from three levels of topography, climate and functional requirements.

II. Strategy of Traditional Rammed Earth Dwellings Based on Geographical Embeddedness

A. Present Situation

The geographical embeddedness of the local traditional rammed earth dwellings is mainly reflected in the master plan, elevation and section of the building. The typical plan features are the back door and the wooden light partition inside the building. The facade features the atrium lighting window, three-section facade included rubble/rammed earth and wooden eaves corridor, and roof terrace space. The section features are mostly related to the local topography, which are mainly shown in the layout along contour lines, facing the mountains and water, multi-entry, the lower storage, overhang eaves and the outer eave corridor, as shown in Fig. 2 for the specific classification and practices.

B. Factor Classification

According to the geographical embeddedness, the influencing factors can be divided into three categories, including topographic adaptation, climatic adaptation and functional adaptation. The current geographical embeddedness

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factors can be classified according to the influencing factors, and topographic adaptation can be further subdivided into landscape environment, terrain height difference and natural texture. Climatic adaptation can be subdivided into thermal adaptation, optical adaptation, wind adaptation and wet adaptation. The functional adaptation can be divided into five functions: living, storage, transportation, drying and culture. The specific classification results are shown in Fig. 3.

Fig. 1 Site of the surveyed villages

1) Spatial Form Determined by Topographic Features

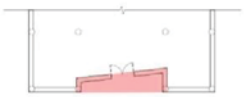
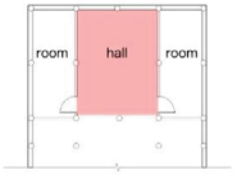
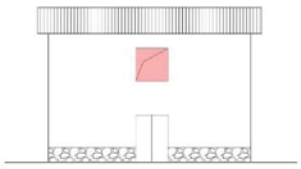
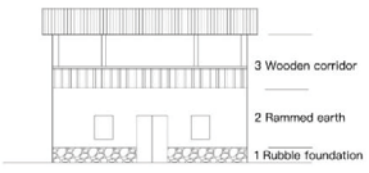
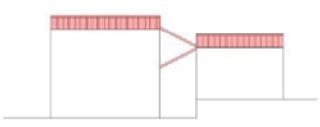
The traditional villages around Baishanzu National Park have beautiful natural landscapes. Influenced by the traditional view of “Feng Shui”, the local traditional villages are mostly back to the mountains and facing the water. In addition, the special geographical environment of mid-altitude hills and the traditional farming and reading culture make local villagers follow the principle of "farming first and then living". The terrain of the building base is often complex, and it is mostly built on the mountain with a large height difference, in a three-dimensional layout, and distributed along the contour line to save land and adapt to the terrain. The tightness of the land allows the villagers to give full play to their wisdom and combine the height difference of the mountain with the building functions. Its architectural pattern includes the practice of using the space with the height difference at the entrance as storage, and setting up multiple entrances to facilitate the actual use. Due to terrain constraints, the volume of residential buildings should not be too large. Small residential buildings are generally strip-shaped, and the number of open rooms is mostly odd.

2) Detailed Treatment of the Influence of Climatic Conditions

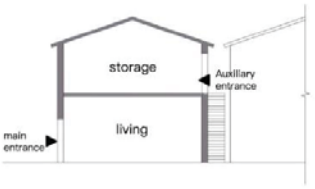
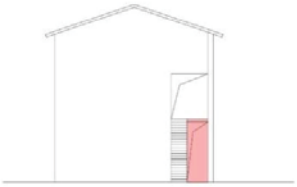
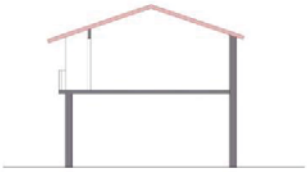
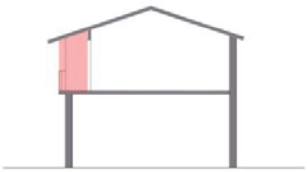
Baishanzu National Park is located in the south of Lishui City, at the source of the Oujiang River and at the junction of Longquan, Qingyuan and Jingning counties (cities). The block belongs to the monsoon region in eastern China, and the subtropical monsoon climate zone. The terrain is mostly mountains and hills, with obvious three-dimensional climate characteristics. Affected by the specific climate, the local dwellings adapt to the climatic conditions through detailed treatment methods. Among them, the local rammed earth material plays the role of thermal insulation to a large extent, and the central hall lighting window, as a local characteristic, improves the living environment in terms of lighting and ventilation. The overhanging eaves protect the wall from rain erosion to a certain extent. In addition, the entrance back door and the outer eaves corridor create a semi-outdoor space, among which the back door has a certain role of guiding wind, and the outer eaves corridor acts as a climate buffer zone, which improves the lighting and ventilation conditions inside the residential. From the perspective of internal structure, the space under the corridor, the bright hall and the patio formed by the eaves corridor, as the "negative" space entity, become the climate adjustment boundary of the entire dwelling. The light wood partition makes the partition of the interior space more flexible and facilitates the opening of windows for lighting.

3)Structural Form of Functional Requirement Change

On the one hand, the geographical embeddedness of traditional dwellings is reflected in the local materials that are restricted by traffic conditions, and on the other hand, it reflects the needs of local farming civilization [4]. Judging from the traditional villages around Baishanzu National Park, most of the local dwellings were originally all-wood structures. Because the material properties of rammed earth conform to the mountain climate conditions and the materials are convenient to obtain, it has gradually become the main building material. However, there is a certain lack of lighting and ventilation. Therefore, it gradually developed into a composite form of "rammed earth & wood structure" in the later period, so that the function and materials were closely integrated. The first floor is used as the main living and activity space, and the outer protective structure is rammed earth, with a floor height of about 3.5 meters. The second floor and above are used as storage spaces, using wooden structures to save costs. The floor height is mainly 2.5 meters. The upper wooden structure is more than 50 cm away from the main building, and an outer porch is set up as a semi-outdoor space for drying. In order to obtain more sunlight and light, the wooden enclosure structure is generally used for the south facade, the three sides are still rammed earth walls, and the load-bearing structure is mostly the wooden structure which is called “Chuan Dou” in China. In addition, the roof of the auxiliary house is sometimes flat, making full use of the height difference space, from the second floor of the main house to the roof of the auxiliary house directly through a ladder, as a drying platform.

Classification	factors	interpretation	sketch	photo
master plan	back door	It reflects the social status and wealth of the owner, shading and guiding wind.		
	bright hall	The horizontal extension is adopted to expand vertically to form a one-line row house, which is conducive to indoor lighting and ventilation.		
	light partition	Flexible division of space for indoor ventilation and cooling		
facade	Lighting windows in the central hall	A hole is opened in the middle of the second floor of the rammed earth wall, and the thickness of the rammed earth wall is used to form a deep window hole, which can not only ventilate but also shade.		
	three-section facade	rubble foundation + rammed earth + wooden eaves corridor		
	roof terrace	In order to save land, the main and auxiliary rooms of local dwellings are also designed with flat roofs, and the internal storage space is directly connected to the roof platform through a ladder, which is used as a drying platform.		

(a)

section	Layout along contour lines	Conform to the terrain and save building materials		
	back to mountains, face river	It can effectively shield the cold north wind in winter, which is conducive to plant growth, agricultural development and soil and water conservation.		
	multi-entry	In accordance with the terrain, multiple entrances and exits facilitate the use of partitions inside the building.		
	Lower spsce for storage	Use the small space on the ground floor for storage.		
	overhang	Shading and reducing the indoor temperature, preventing the rainwater from directly scouring the rammed earth wall.		
	eaves corridor	the drying/activity space		

(b)

Fig. 2 Representation of geographic embeddedness

C. Typical Factor Analysis

From the perspective of geographic embeddedness, rammed earth material has good heat storage, thermal insulation properties, and can be used locally. Therefore, local traditional villages often use rammed earth as the enclosure structure, but it is restricted by construction technology and in order to meet the needs of anti-theft and achieve better thermal insulation effect, the wall should not open windows or open small windows as much as possible, so there are problems in lighting and ventilation. In order to solve this contradiction, the local dwellings mostly adopt design techniques such as central hall lighting windows, light wood structure composite exterior walls, and skylight lighting.

1) Lighting Windows in the Central Hall

The lighting windows in the central hall are mainly found in three-story dwellings, that is, a hole is opened in the middle of the second floor of the main facade, and a ventilation loft is formed by using the lighting and ventilation hole. This practice is more common in dwellings with larger depths. On the one hand, the lighting environment of the rooms on both sides can be improved through the lighting windows in the middle hall, and on the other hand, it also has the effect of guiding the wind, making the overall ventilation effect of the residence better.

geographic embeddedness factor			master plan			facade			section					
			back door	bright hall	light partition	Lighting windows in the central hall	three-section facade	roof terrace	Layout along contour lines	back to mountains, face river	multi-entry	Lower space for storage	overhang	eaves corridor
topographic adaptation	landscape environment								●	●				●
	terrain height difference							●	●		●	●		
	natural texture						●							
climatic adaptation	thermal adaptation	heat preservation					●							
		drop temperature		●	●	●								
		shading	●			●							●	●
	optical adaptation	lighting		●	●		●	●	●	●				●
	wind adaptation	ventilation	●	●	●	●	●		●	●	●			
	wet adaptation	rain proof											●	●
		Moisture proof					●						●	
functional adaptation	living						●							●
	storage					●						●		
	transportation										●		●	
	drying							●						●
	culture		●	●						●				

Fig. 3 Classification of geographically embeddedness impact factors

2)Composite "Rammed Earth & Wood Structure"

Affected by the terrain and climate, and considering the functional needs of the dwellings, local traditional dwellings are often made of local materials, using rammed earth, wood, etc. as the main building materials. Therefore, it forms a typical three-section composite facade of "rubble foundation + rammed earth + wooden eaves corridor". In addition to the consideration of the physical environment and the cost of construction, the selection of the outer protective structure also has an important criterion that needs to meet the fire protection needs. When the buildings are closely arranged, the surrounding rammed earth is usually selected to prevent fire, and when the houses are scattered, the rammed earth in the lower part and the wooden structure in the upper part are often used to obtain better ventilation and lighting.

3) Skylight Lighting

In order to improve the internal lighting conditions of some dwellings, the villagers also choose to set up skylights on the roof, that is, to replace some small tiles with bright glass tiles, and combine with the partial overhead on the second floor, so that the light from the top can shine on the main living space on the first floor, improving the quality of light environment. There are also some large-scale courtyard-style dwellings that partially set up lighting wells on the second floor to enlarge the lighting nodes and introduce light into the first floor.

III. Modernization of Traditional Rammed Earth Dwellings

A. Geographical Disembedding Process of Traditional Rammed Earth Dwellings

The traditional rammed earth dwellings are the result of the trinity of "people, architecture and nature". It is built in accordance with the trend, and fully utilizes the performance characteristics of various materials to achieve the unity of function and form. In addition, the use of wood structures also makes the space division more flexible, which has extremely high practical value and cultural value. However, with the migration of the times, the performance defects of traditional dwellings and the mismatch with modern functions have gradually become prominent. In order to solve these problems, local villagers mostly choose to demolish and rebuild on the original site, and the new brick or concrete houses are separated from the style of the village, and showing the phenomenon of convergence and dissimilarity, while relying on active technology and high energy consumption, this process can be called "geographical disembedding". The disappearance of the landscape and cultural genes contained in the local traditional rammed earth dwellings is the dual disappearance of the local culture, which needs our attention.

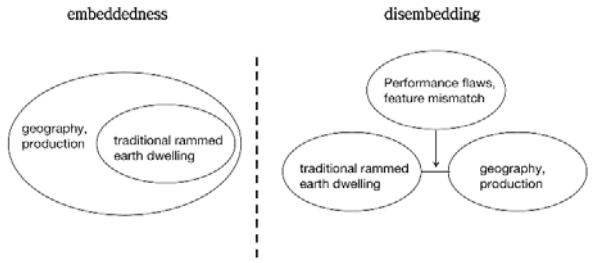


Fig. 4 Geographical disembedding process

B. Influencing Factors of "Geographical Disembedding" of Traditional Rammed Earth Dwellings

1) Replacement of Building Materials

Constrained by economic and traffic conditions, traditional dwellings are mostly sourced locally. The villages around Baishanzu National Park are rich in environmental resources and have a high forest coverage rate. Therefore, wood and rammed earth are widely used in residential buildings as local materials. The rammed earth house is warm in winter and cool in summer, with high living comfort, and local materials are used at low cost. After the 1990s, the reform and opening up greatly liberated productive forces, promoted economic development, and continued to improve infrastructure. Brick was popular throughout the country as a new building material because of its convenient firing and stronger durability. Influenced by this upsurge, traditional villages gradually replaced the facades of rammed earth dwellings with brick walls. In recent years, frame concrete has become the mainstream building material. The new concrete materials are quite different from traditional rammed earth and wooden materials in style and appearance, and new buildings are inconsistent with traditional dwellings.

2) Change of Use Function

Traditional villages have a typical "geographical embeddedness" feature [8], which is manifested in two aspects: firstly, it is reflected in the local characteristics of building materials mentioned above; secondly, the building functions must meet the needs of living and production at that time, so behind the material replacement corresponds to the change of the corresponding use function. Traditional rammed earth dwellings are mostly two-story, and a few will add an extra layer to expand the living space. Taking the two-story dwelling as an example, according to the material characteristics, the first-story rammed earth enclosure is mainly used as a living place, including the hall, bedroom, kitchen and other spaces, which are connected to the second floor by wooden stairs; the second floor is mostly used as storage space for stacking farm implements. etc., the demand for thermal insulation is low, so it is common to use wood as the outer protective structure, which can improve the ventilation and lighting of the first floor space to a certain extent. In addition, there are many wooden eaves corridors on the second floor as drying spaces. In order to obtain sufficient sunlight, the eaves corridors are often set on the south side, and more attention is paid to the orientation. This kind of composite structure meets the basic living needs of the local villagers in the last century.

With the development of the economy, the number of villagers engaged in traditional farming has gradually decreased, so the demand for large-scale storage space has also decreased. With the improvement of construction technology, the use of brick walls and concrete has improved the comfort of the living space. In terms of use, more emphasis is placed on the living space and the storage space is compressed. The spatial function is no longer a three-dimensional distribution in units of "layers", but a hybrid arrangement, that is, the storage space is interspersed in the living space. Therefore, the dwellings have undergone great changes in the plan and facade.

3) Improvement of Quality of Life

The geographical disembedding of local dwellings also reveals the improvement of the quality of life of the villagers. With the development of the economy, the local villagers have also put forward higher requirements for the living conditions. Due to the limitation of construction technology and the need for anti-theft, the traditional rammed earth structure brings poor lighting and ventilation effects, and their durability is poor in that they are easily eroded by rain. The authenticity of the material itself is lost, and the overall architectural effect is not good. Therefore, in recent years, newly-built residential buildings generally use brick walls or concrete materials, which are freer in opening windows, and the indoor and outdoor cleanliness are also higher, which greatly improves the living experience. Of course, to a certain extent, this also reflects the changes in the villagers' architectural aesthetics. Rammed earth houses are mostly symbolized as a symbol of poverty. Therefore, traditional rammed earth dwellings are replaced by cement brick buildings.

C. Geographical Re-Embedding of Traditional Rammed Earth Dwellings

Based on the analysis of the influencing factors of geographic disembedding and the embeddedness factor analysis above, in order to realize the geographic re-embedding of traditional rammed earth dwellings, it is necessary to start from two aspects of performance and function. On the one hand, it is necessary to upgrade the performance of traditional dwellings to improve indoor lighting, ventilation and thermal environment to meet the needs of modern living. On the other hand, it is also necessary to transform the traditional use functions to meet modern use in terms of scale and other aspects, such as increasing the living area through the re-division of indoor space, or considering the extension of functions, such as the development of homestay. Therefore, it is necessary to integrate the above-mentioned elements, and use new materials and technologies to update traditional dwellings.

Taking the homestay "Ruyin·Xiaozuoju" in Jingning County, Lishui City as an example, the homestay adopts the traditional rammed earth shape and uses new rammed earth materials to improve the durability of the wall. The lighting and ventilation defects brought by the large windows enhance the indoor living comfort. In addition, the eaves corridor is widened to serve as the outer balcony of the indoor guest room,

transforming the traditional drying and lighting space into a leisure functional space. At the same time, lamps are arranged in the space above the eaves corridor to provide night lighting to meet the needs of night use.

Fig. 5 "Ruyin·Xiaozuoju"

IV. Conclusion

Traditional rammed-earth dwellings fully reflect the construction of suitable traditional human settlements, which are in line with the environment in terms of terrain, climate and functional requirements, and have a very high "geographical embeddedness". Therefore, in the era of comprehensive modernization, we should continue to preserve traditional architecture. On the basis of field investigation and research, from the perspective of embeddedness theory, this paper sorts out and categorizes the passive strategies of local suitability, and provides a reference for the renewal and optimization of traditional dwellings in southern Zhejiang. In the future renovation, the core value embodied should be protected and inherited, and modern materials should be combined with traditional rammed earth dwellings, so as to improve the living quality while retaining the traditional rural atmosphere.

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