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Research into the Climate Adaptability Created by Human Settlement of Traditional Villages in Hunan

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Abstract: In order to understand the current condition of traditional villages' human settlement in Hunan area, this research team, taking 21 traditional villages in southern Hunan area as its research subject, qualitatively analyzed the adaptability of traditional villages' human settlement to three aspects as natural disastrous climate, daily climate, as well as long-term natural climate through field research and survey in the summertime of 2015. At the same time, typical traditional dwellings and the newly-built ones in Village Shang Gantang, "a millennium ancient village", were selected as testing subject. The indoor thermal comfort degree of this village's dwellings was investigated and analyzed through simulation analyzing and on-site testing the sunshade and wind speed of street-lane, indoor space temperature of traditional dwellings, and indoor temperature and humidity of different enclosure structures in the manner of questionnaire. It was found after the results that: traditional villages are equipped with sound climate adaptability in such aspects as site selection and distribution, indoor functional layout and enclosure structure construction, etc, to bring sound natural ventilation effect by making the most of the laneways and courtyard; local traditional dwellings adopt enclosure structure with big thermal inertia to generate relatively good heat prevention effect to create a sound indoor heat environment under a joint influence of "transitional space" and "climactic space". In addition, though the indoor humidity exceeds human body comfort degree in the summertime of traditional dwellings, still local dwellers are relatively adaptive in general. At last, constructive suggestions are proposed to the designing of new villages' human settlement by combining the features of traditional villages.

Keywords: *Traditional village, Human settlement, Passive technique, Climate adaptability*

1. Introduction

Traditional villages, referred to as the "living fossils" and "museums" of the rural history, and nature, etc, are villages in possession of cultural heritage in material and immaterial forms with relatively higher values in history, culture, science, art, society and economy, which witness the process of human being's long-term adaptation to, transformation of, as well as harmonious co-existence with nature, reflect the advancement of social civilization, and crystallize the historical memory. To save and inherit traditional architectural culture, four departments and commissions at the national level have organized the investigation work on traditional villages to list 2555[1] traditional villages among 12000 villages possessed with traditional nature nationwide into The Directory of Chinese Traditional Village (hereinafter referred to as Directory) after appraisal by experts in three batches.

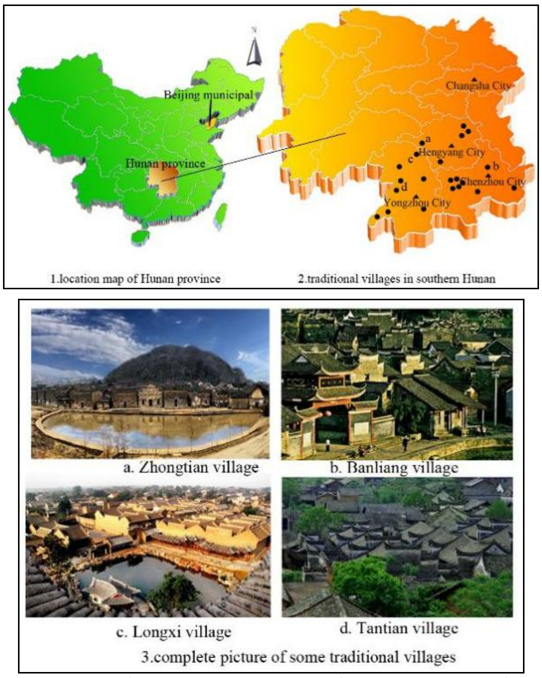
There are a number of traditional villages in the area of Hunan, with more than 700 traditional villages have been found with protective value provincially. Among them, 91 were listed into the Directory, with 21 from southern Hunan area. The previous research of the traditional villages in Hunan area was more focused on humanity and history, mainly centralized by site selection, space configuration as well as architectural type, etc [2], while less on ecological experience and technical support. Therefore, in order to delve into the climate adaptability of traditional villages' primitive human settlement, the author quantitatively analyzed the climate adaptability of 21 traditional villages in southern Hunan area from the perspective of architectural techniques in the aspects of site selection and distribution of villages, the heat, dampness and fire prevention of street-lane and courtyard spaces, etc; conducted comparative testing on the thermal environments between indoors and outdoors by taking representative traditional and newly-built dwellings of Village Shang Gantang, a typical traditional village as research subject. The contributions and limitations of traditional dwellings' space distribution and enclosure structure construction to the adaptation to regional climate were discussed with qualitative actual measurement results so as to provide fundamental references for the improvement and upgrading of traditional villages' human settlement.

2. Research Area and Methods:

2.1. Research Area:

2.1.1. Natural Environment of Southern Hunan Area: Southern Hunan is referred to three cities, Hengyang, Chenzhou, and Yongzhou as well as various counties located in the south of Hunan. With a total population of 17, 97 million (by 2010), it covers a total land area of 57,153 square kilometers. This area, commonly known as "70% hills, 10% waters, and 20% farmland", is mainly featured with hills, which are about the same height, and few water surfaces. Located in the central and sub-tropical continental monsoon climate zone, Southern Hunan area is hot in summer while cold in winter with an annual temperature of 17℃~18℃ on average. The hottest month of the whole year is July, with 29.3℃ of average temperature and 566.4.6 MJ/m2 of solar radiation intensity; the coldest month is January, with 7.4℃ of average temperature and 173.2 MJ/m2 of solar radiation intensity. The whole year sunshine duration is 1500~1700 hours, the average annual precipitation is 1250~1750 millimeters, and the yearly relative humidity is about 80%.

2.1.2. An Overview of Traditional Villages in Southern Hunan: Up till now, there have been 209 traditional villages worth protection in southern Hunan area, among which, 71 are from Hengyang City, with 5 listed into the Directory; 91 from Chenzhou City, 8 listed; 47 from Yongzhou City, 8 listed, all shown as Figure 1.



PS: Data are from the Management Information System of the Ministry of Housing and Urban-Rural Development of the People's Republic of China

***Figure.1** Distribution Diagram of Traditional Villages in Southern Hunan Area Being listed into the Directory*

Hunan Province has been a vast territory with a sparse population ever since ancient times. Influenced by factors such as chaotic warfare, heavy taxation, and population expansion, etc, populations outside the province have sporadically immigrated into Hunan ever from Tang Dynasty to later Qing Dynasty. The results of analysis into the causes of formation of traditional villages in southern Hunan are shown as Figure 2: (1) Years of formation: 13 and 6 villages were built in Ming Dynasty and Qing Dynasty, taking up 61.9% and 28.6% of the total respectively. (2) Reasons of formation: one is immigration, which is the major reason to form the villages, with 12 in total, accounting for 57%; the other is generation, 7, 33.3%, which come from the continuous expansion to the surroundings by local dwellers; still another is military, whose formation is in relation to ancient military activities, altogether 1; and the last one is the influence from transportation location and trade activities, also 1 in total.

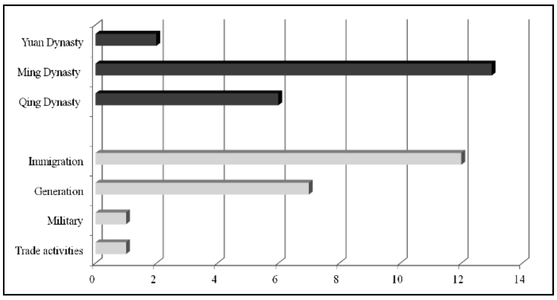


***Figure 2:** The Formation Years and Reasons of the Hunan Traditional Villages*

2.2. Research Methods:

2.2.1. Qualitative Induction: This paper qualitatively analyzed the climate adaptability [3] of traditional villages from three perspectives of natural disastrous climate, daily climate, as well as long-term natural climate through field studying, surveying and mapping of traditional villages in southern Hunan area. The study processes are as Figure 3.

2.2.2. Quantitative Analysis: By choosing typical dwellings built in different years and manners against the same environment in Hunan area (southern Hunan), this research continuously tested environment (temperature, humidity, wind speed) both indoors and outdoors, and analyzed the indoor environment of traditional villages as well as the reasons leading to the different feelings towards indoor thermal comfort in combined with software simulation and the thermal and humidity feelings of local dwellers. The research processes are shown as Figure 4.

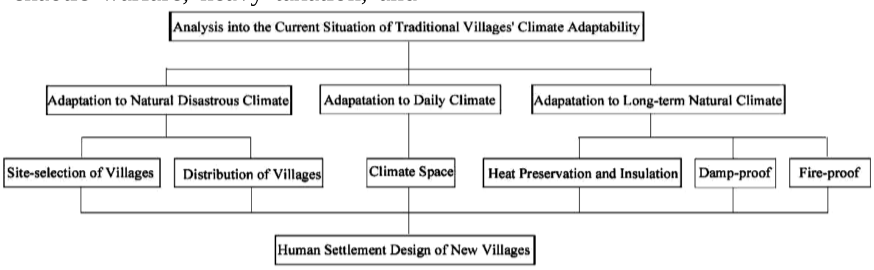


***Figure 3:** Qualitative Analysis into the Traditional Villages' Human Settlement*

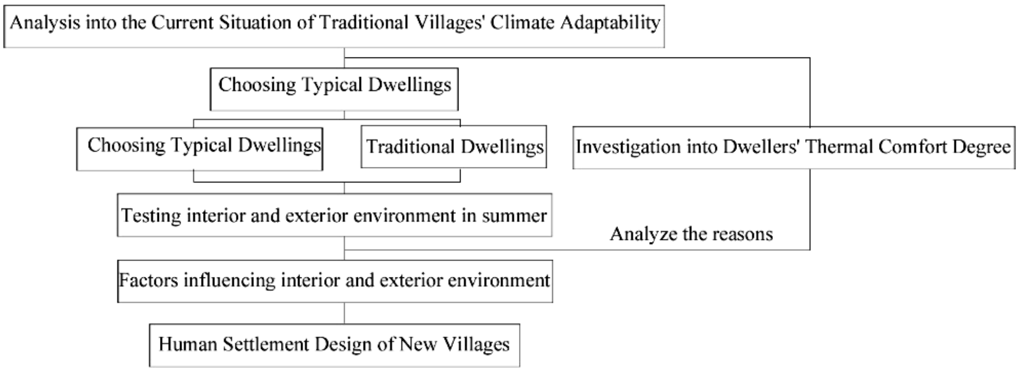


Figure 4: *Quantitative Analysis into the Traditional Villages' Human Settlement*

3. Climate Adaptability Creation System of Traditional Villages' Human Settlement:

3.1. Adaptation to Natural Disastrous Climate:

3.1.1. Villages' Site-selection facing the Waters with Mountains on the Back: Mainly inhabited by Han ethnic group, the site selection of the traditional villages in the southern Hunan formulates a basic pattern of "southern exposure, water exposure, sun exposure", with the planning idea indicated with Fengshui environment, themed with idyllic life, and conceived by patriarchal rituals, which is shown as Figure 5 [4].

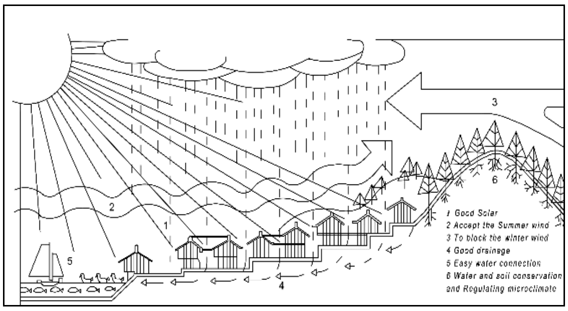


Figure 5: *Climate Factors and Villages' Site-selection*

The distribution, "facing the waters with mountains on the back" of traditional villages is both a response to site environment as well as people's adaptation to climate environment. "Mountains on the back" can prevent the north-west wind and polar invasion in winter, to create a sound outdoor environment; in addition, dwellers living in the villages can obtain ideal daylights to satisfy the requirements of interior lightening, which is helpful to physical and mental health. In summer, natural wind blow the moist air of water ponds, and farmlands, etc. to the architectural complex inside the villages from the "facing waters" side of traditional villages thanks to wind pressure; furthermore, a huge space of street-lane and courtyard inside the villages form good air passages to bring ideal draughts throughout the entire villages, so that the problem of traditional dwellings' ventilation is effectively resolved. Meanwhile, southern Hunan area is characterized by mountains and hills, where traditional villages utilize the loftiness and the level differences scattered front and back of the mountains to quickly drainage the precipitation in the rainfall season [5], so that the villages are free from flood disasters.

3.1.2. Compact and Dense Villages Distribution: Street-lane is both a framework to form the space configuration of traditional villages (Figure. 6), as well as the main public space of villages. The lane roads of traditional villages in southern Hunan area are complex and complicated. There are mainly three layers of street-lane space, namely, entrance street (a width of 2.5m~3m), semi-open lane road (a width about 2m) and closed alley (a width of 0.8m~1.5m).

Most dwellings in the traditional villages have 2 floors, with a height-width ratio of architecture and street-lane being 5:1~10:1 in general, which impresses people with a visual perception of "high walls and narrow lanes". Such a space configuration is a result of traditional villages' adaptation to climate in southern Hunan area. High exterior walls and narrow street-lanes are advantageous to the sunshade among dwellings in summer, to form comfortable space both indoors and outdoors by lowering the lanes' and indoor temperature.

3.2. Adaptation to Daily Climate:

As early as agrarian society, Hunan traditional villages have already come up with "climate space" to deal with sticky weather, such as exterior corridors, attics, balconies, courtyards, etc. Each and every climate space does not exist independently; instead, they have an effect of interactive linkage to resolve the problem of thermal comfort inside the dwellings environment through a joint action. Three representative kinds of type space [6] are concluded by means of categorizing the commonality of traditional villages' spatial forms in southern Hunan, namely, "street-lane + courtyard" space, "traversed corridors + courtyard" space and "exterior corridors + attics" thermal buffer space as shown in Figure 7.

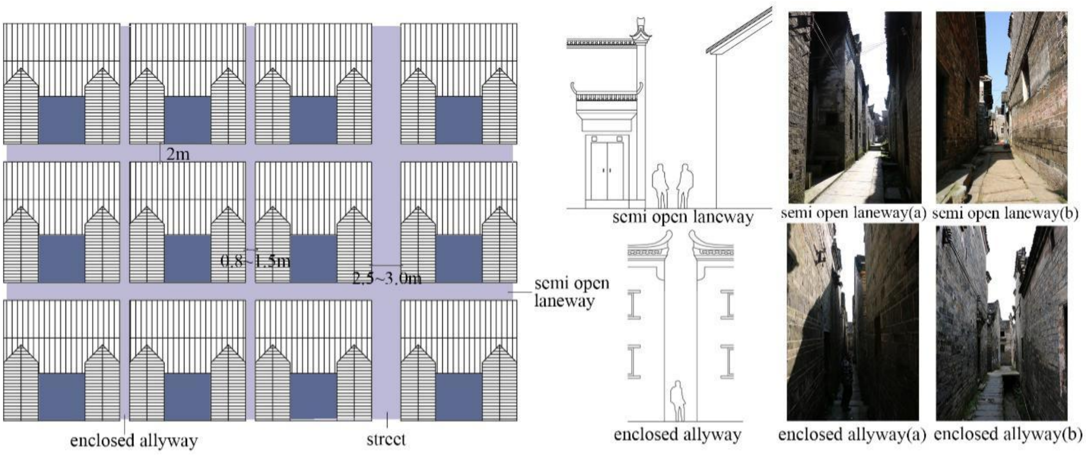


Figure 6: *Compact Distribution of Hunan Traditional Villages*

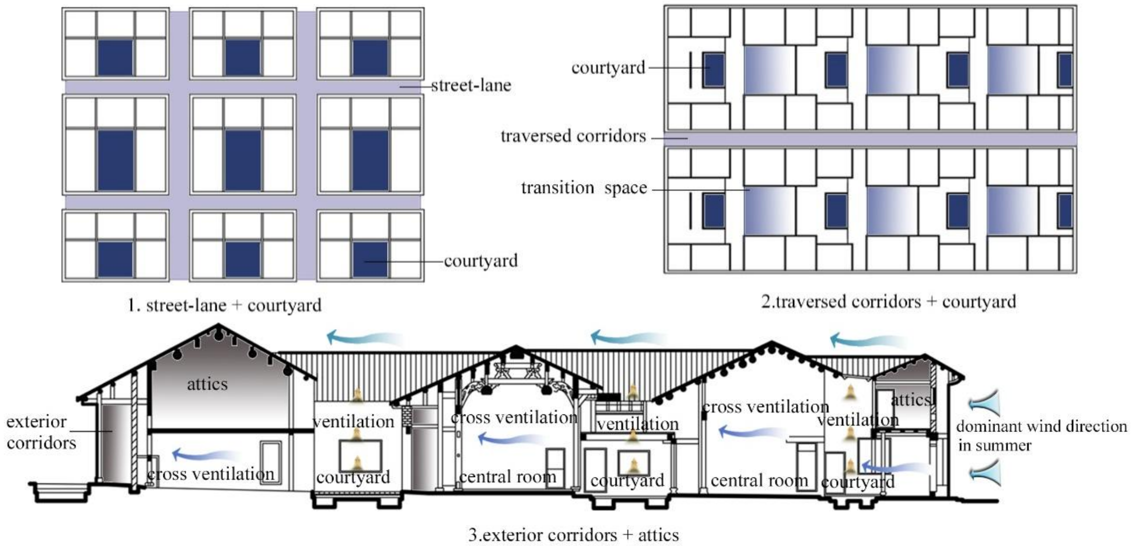


Figure 7: *Representative Types of Hunan Traditional Architectures "Climate Space"*

3.3. Adaptation to Daily Climate:

3.3.1. Thermal Preservation and Insulation: The walls of traditional dwellings adopt the raw soil material with big thermal inertia, such as black brick and adobe, etc, which are advantageous in cooling, thermal insulation, preservation and accumulation, to effectively deal with climate change; wood materials serve as dwellings' structural materials through mortise and tenon components to effectively resist to gales, earthquakes, as well as other disasters, and meanwhile preserve heat and insulate sound.

3.3.2. Architecture Damp-proof: The floors of traditional dwellings generally adopt brick-stone and concrete to consolidate the buildings, which serves sound damp-proof. The adoption of granite black-brick for masonry laying about 1 meter above the dwellings' walls is advantageous to prevent against humidity at the wall base; wood column adopts stone column as its base to prevent against humidity. At the same time, by taking advantage of the architectural surface with the most stability in ground thermal property, traditional dwellings in this area introduce the air outside into the tunnels, whose soil will be utilized to reduce the temperature. The air, after being cooled down itself, cools down the halls and bedrooms in the manner of radiation, and convection, etc, to achieve the cooling effects at last. It can be told that such a traditional way is the prototype [8] of ground source heat pump, a modern hi-tech.

3.3.3. Dwellings Fireproof: The fireproof design of traditional villages are mainly demonstrated in the following aspects: first, use non-combustible materials, such as bricks, stone, and soil, etc; or process combustible materials into non-combustible ones, such as painting tung oil onto timber component, or use brick-stone and other refractory materials to package and shelter timber component. Second is to prevent the fire from spreading through fire seal. And the third is not to open the window between two gable walls, which can also effectively prevent fire.

4. Testing on Human Settlement both Indoor and Outdoor the Dwellings and the Result Analysis:

4.1. Testing Background:

4.1.1. Testing Subject: In order to further understand the current situation of thermal environment both indoors and outdoors of Hunan villages' traditional dwellings, this research chose Village Shang Gantang of Yongzhou City as the testing subject. Village Shang Gantang, with 453 households of dwellers, 1865 people in total, is a millennium ancient village enjoying the longest time duration found in Hunan Province. There is over 200 dwellings in the village, most of which can be dated back to Ming and Qing Dynasties, or the Republic of China era. Be deposited with China's ancient patriarchal rituals, Confucius traditions, Fengshui concepts, philosophical awareness, architectural techniques, and ecological principles, the entire village is a typical Hunan clan cluster. Renowned as "China's famous village with history and culture", it is the museum of Hunan traditional dwellings, and folk culture.

Two representative and well-preserved dwellings in the village were selected as testing subject. One was a black brick dwelling (Figure 8), built in Qing Dynasty with well-maintained main body; while the other was a raw soil one, which was built in the early 20th century with still maintained original appearance of the main body. In order to compare their effects of interior thermal environment, another local modern residence in representative (built in 2005) was also selected out to test its interior temperature and humidity. The dwellings and its structure selected are shown as Table 1.

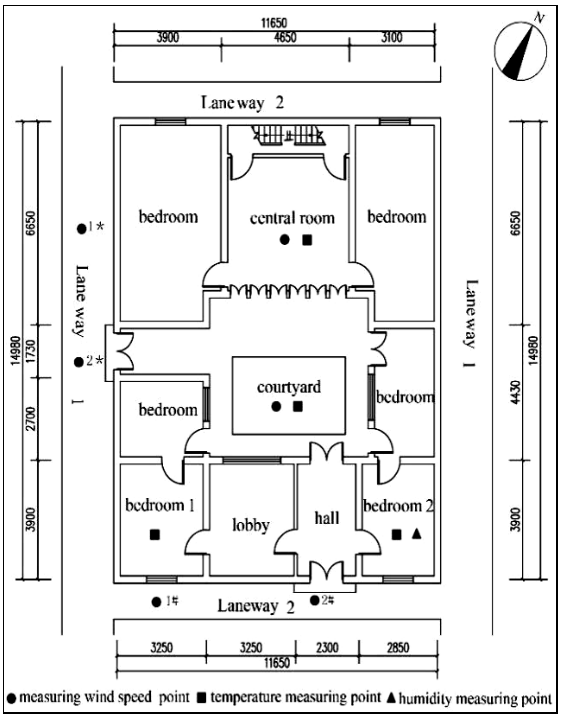


Figure. 8 *The Plane and Testing Points Distribution of Traditional Black-brick Dwellings*

4.1.2. Testing Plan: In order to make the data tested persuasive, the testing time was chosen from Jul. 15th to Aug. 4th, the hottest period in summer, lasting 20 days.

Instruments for tests are indicated in Table 2, and the sites are indicated in Figure 8. Portable meteorological station was set up in the roof, without obstacles around. Self-recording thermometer was placed 1.5m above the ground, with aluminum foil wrapped to prevent the light radiation from affecting temperature measured. The height to test interior wind speed was 1.5m. The tests began at 9:00 and 15:00 every day, and the data were recorded at an interval of 20s within 2 min. Before testing, all the testing instruments were re-calibrated, and some instruments on site were readjusted to zero before every test to ensure the accuracy of data tested.

4.2. Testing Results and Analysis:

4.2.1. The Influence of Street-lane Space on Human Settlement: (1) Laneway sunshade. According to the dwelling's plane with actual measurement, and model built in Ecotect, the shading analysis was conducted on July 23rd, the day with the strongest radiation in typical year. The dark part in the picture stands for the shaded shadow parts. It can be known from Figure 9 that at 13:45, the laneway was exactly shaded by the east walls to stay inside the shadow entirely; while at 14:00, 15:00, 16:00and 17:00, the average height of the shadow parts of the west walls is 0.8m, 2.5m,3.8m and 4.2m in respective (Figure 9), which is a very good effect of sunshade. As it proves that the rich street-lane space in Village Shang Gantang enables the inter-sunshade among dwellings to form abundant shadow area, which is typical "cold lane" [9] to constitute dwellings' climate buffer zone.

(2) Laneway wind. In order to know about the wind speed of transitional and open space, this research conducted actual measurement of the wind speed of laneway and central room [10]. The test points of interior wind speed, as indicated in Figure 8, are outdoors, central room, courtyard, laneway 1 and laneway 2, and the reason is that residents are accustomed to these places for activities in summer, and the speed of wind directly influences the comfort degree of human body. Table 3 lists the average wind speed within 5min of all the testing points from July 22nd to July 25th. It can be drawn from Table 3 that: the wind speed of laneway is about as comfortable for human body as 0.3m/s, and basically higher than that of the central room and courtyard, with the maximum of 0.51m /s. This is because laneway is narrow, and its "valley effect" is able to accelerate the wind mobility, which is an extra benefit brought by high density distribution; the average wind speed of laneway 2 is faster than that of laneway 1, which illustrates that in traditional villages, the narrower the laneway is, the faster the wind speed, and the more apparent of its valley effect. Central room's wind speed remains relatively stable, basically 0.1m/s~0.3m/s even on the condition when the outdoor wind speed is relatively low (only 0.06 m/s). And this is because central room faces open to the courtyard, which makes it possible to improve the interior natural ventilation, but its wind speed is lower than that of the courtyard.

Table 1: *Background of Testing Architecture*

Name	Raw soil dwelling	Black brick dwelling	Modern architecture
Orientation	East-west	East-west	East-west
Layer	Single layer with an attic	Single layer with an attic	Two layers with an attic
Height	3.0 m	3.0 m	3.3 m
Roof	Double-layer, small gray tilt pitched-roof	Double-layer, small gray tilt pitched-roof	Single layer mechanical tilt pitched-roof
Wall materials	Adobe(390mm×260mm×130 mm)+lime mortar(20mm)	Black brick(300mm×200mm×100 mm)+lime mortar(20mm)	Red brick(240mm×120mm×60 mm)+lime mortar(20mm)
Opening features	East-west, with sunshade, open to central room or courtyard, fixed window	East-west, with sunshade, open to central room or courtyard, fixed window	East-west, without sunshade, directly open to outdoors, sliding window
Opening size	Height: 1360 mm; Width: 1180 mm	Height: 1360 mm; Width: 1180 mm	Height: 1 800 mm; Width: 1 500 mm

Table 2: *Parameters and Instruments for Tests*

Parameters	Instruments	Models	Accuracy	Notes
Exterior temperature	Portable meteorological station	NHQXZ602	±0.2℃	Self-recording at 10 min interval
Interior temperature	Self-recording thermometer and hygroscope	WZY-2	±0.3℃	Self-recording at 5 min interval
Interior wind speed	hot wire anemometer	QDF-6	±3% m/s	Manual recording

Table 3: *Average Wind Speed both Indoors and Outdoors (m/s)*

Locations		July 22nd		July 23nd		July 24nd		July 25nd	
		9:00	15:00	9:00	15：00	9:00	15:00	9:00	15:00
Outdoors		1.83	0.12	1.69	0.25	0.06	0.24	0.47	0.27
Central room		0.13	0.16	0.23	0.17	0.09	0.11	0.12	0.21
Courtyard		0.15	0.18	0.25	0.24	0.14	0.16	0.23	0.31
Lane way 1	1	0.16	0.22	0.31	0.28	0.18	0.17	0.34	0.38
	2	0.25	0.33	0.39	0.33	0.21	0.19	0.38	0.25
Lane way 2	1	0.39	0.44	0.51	0.47	0.35	0.34	0.45	0.47
	2	0.37	0.41	0.49	0.43	0.26	0.32	0.39	0.33

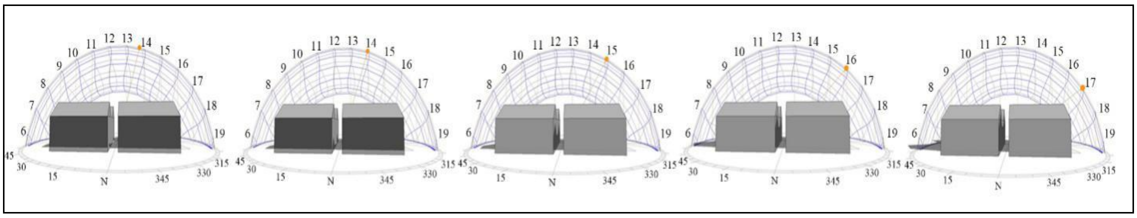


Figure 9: *Shading Analysis into Laneway*

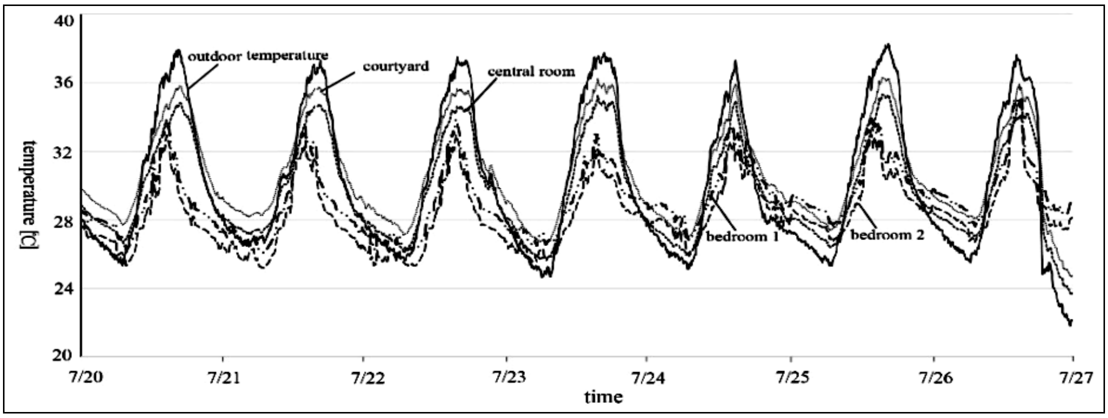


Figure 10: *The Interior Temperature of Each and Every Space of Traditional Dwellings*

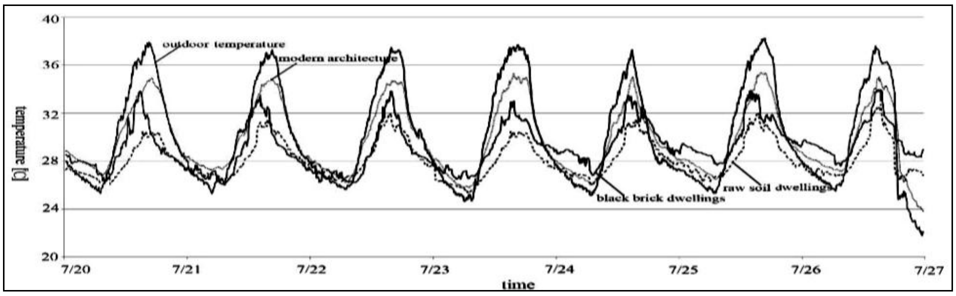


Figure 11: *Comparison of Indoor Temperature among Traditional Adobe, Black Brick Dwellings and Modern Residence*

4.2.2. The Influence of the Functional Space Layout on Human Settlement: The interior temperature of each and every space of dwellings is shown as Figure 10. The temperature of all the interior space is generally lower than the exterior one in the daytime, vice versa in the evening [11]. Temperature inside the bedrooms remains quite stable with relatively smaller amplitude of fluctuation in comparison with the one outside, which demonstrates that, living room and other transitional space can effectively reduce the effects of scorching exterior climate on the main living space inside. Living room serves as transitional space, and its temperature is higher than that of the room in the daytime thanks to the likely influence by the exterior climate on it as transitional space. The interior temperature of bedroom 1, 29.21℃ averagely, is 1.3℃ higher than bedroom 2's; the maximum, 35.04℃, 1.05℃ higher than bedroom 2's. It is because that: in addition to the solar radiation exposing to the south of bedroom 1, its west walls are also influenced by solar radiation, which is even more serious. And therefore, the interior temperature is high. However, bedroom 2 only has its south walls exposed to solar radiation, and thus its interior temperature is lower than bedroom 1's. These phenomena illustrate that the transitional space inside traditional dwellings, as the "buffer zone" for climate, weakens the influence of natural climate on the main space used inside the buildings.

4.2.3. The Influence of the Enclosure Structure Construction on Human Settlement: (1) The interior thermal environment test of different enclosure structures. The rooms' interior temperature of traditional dwellings and modern architecture is compared on the basis of the principle of being heated, becoming similar indoors [12], and the actual measurement results are shown as Figure 11. Generally speaking, the temperature inside the rooms of traditional dwellings is constantly lower than the modern residence's temperature, while raw soil dwellings' lower than black brick dwellings'. The maximum and average of raw soil dwellings is 2.66 ℃ and 1.62 ℃ lower than those of modern residence, while the maximum and average of black brick dwellings is 1.43 ℃ and 0.62 ℃ lower than those of modern residence. This confirms the conclusions drawn from previous research: The thermal transmission index of adobe wall, black brick and modern architecture's enclosure structure is 1.27 $W/m^2 \cdot K$, 1.77 $W/m^2 \cdot K$ and 3.15 $W/m^2 \cdot K$ in respective [13]. And their thermal inertia index is 5.17, 3.62 and 2.47 respectively. With better thermal performance than that of modern brick wall, the traditional dwellings' wall has better heat preservation and prevention effects, as well as sunshade design, which enables its lower interior temperature compared with modern architecture's in the summertime. Furthermore, larger window-wall ration of modern architecture also constitutes one of the reasons that the interior temperature is relatively higher. When making use of traditional dwellings, local residents prefer to stay in the opening and shading transitional space to pursuit the comfortable natural ventilation. After dwellers having moved to modern residence, a lack of transitional space leads to their expansion of the bedroom opening to pursuit natural ventilation, plus the inconsideration of shading design, eventually the interior thermal environment [14] with poor comfort degree was resulted in. Henceforth, it is one of the key problems in need of consideration to adopt proper window-wall ration and also to add suitable shading when designing modern rural residences.

(2) The interior humidity test of different enclosure structures. In order to know about the relative humidity inside the dwellings of traditional villages, humidity data of 7 days in successive are selected to analyze, the result of which is shown as Figure 12.

It can be known from Figure 12 that the air relative humidity inside the traditional dwellings and modern residence is relatively higher as a whole, featuring low in daytime, while high in the evening. The air humidity inside the raw soil dwelling buildings has relatively higher relative humidity value, which maintains about 80%; the air humidity inside the black brick dwellings is the second, with relative humidity maintaining about 75%; and the humidity inside the modern residence, lower than that of traditional dwellings, maintains about 70% of relative humidity. As for the reasons: adobe wall belongs to porous medium. Its small penetration resistance against steam makes the moisture more likely to diffuse from the side where the partial pressure is large to the one is small. Raw soil dwellings are able to adjust the humidity to a certain yet limited extent. The long time also leads to the severe damage to the inner moisture barrier layer. Therefore, with much higher humidity inside the raw soil dwellings, it is prone to have dampness. Black brick wall has a larger penetration resistance against steam than adobe structure does, which is effective to resist against the penetration of part of water steam, bringing low interior relative air humidity. Though the ground and wall corner of traditional black brick dwellings and modern residences have been processed with damp proof, still the gas tightness of traditional dwellings' enclosure structure is poor to form air leakage easily. By leading the high-humidity air outdoors to indoors, the interior relative humidity of traditional dwellings' enclosure structure is higher than that of modern residence. Therefore, increasing the tightness of the room, particularly upgrading the ability to adjust the humidity for traditional dwellings' enclosure structure is a significant approach and measure to decrease the interior humidity, as well as improve the interior thermal comfort degree.

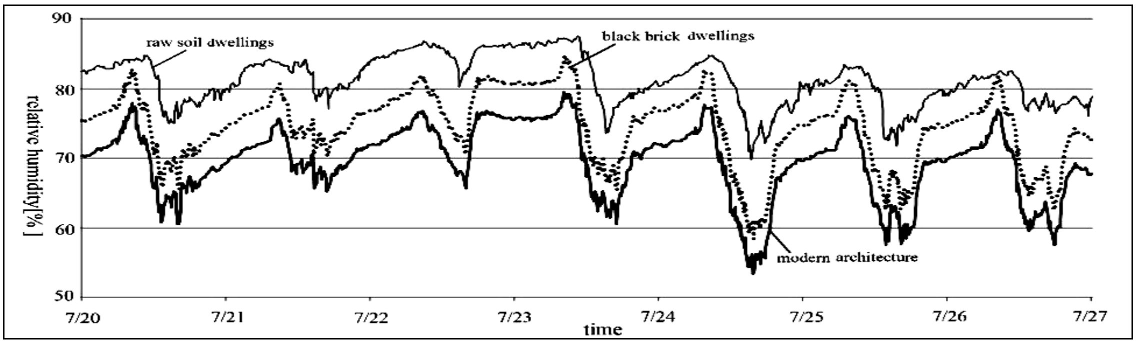


Figure 12: *Comparison of Relative Humidity inside the Traditional Dwellings and Modern Residence in Summer*

4.3. Investigation into the Thermal Comfort Degree of Villages:

The thermal comfort situation of Village Shang Gantang is analyzed by applying Givoni's method [15] of designing and analyzing architectural climate, which is shown as Figure 13, and from it, it is known that the climate of Village Shang Gantang is basically beyond the range of comfort degree.

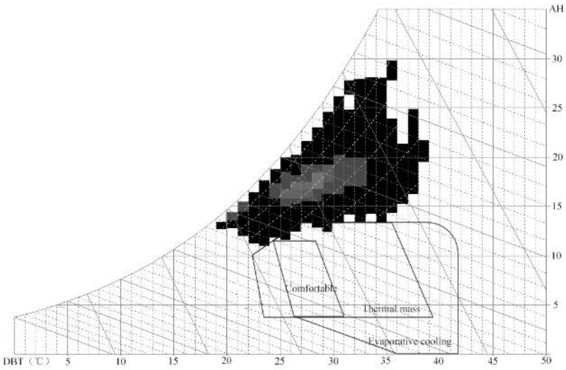


Figure 13: *The Effective Range of Various Passive Measures in Improving Thermal Comfort Environment in Summer*

In order to fully understand the feelings of Shang Gantang villagers towards the thermal environment inside the dwellings in summer, the authors randomly chosen 100 households' residents (including residents tested) of all the testing points in summer to conduct questionnaire, which includes[16]: 1) the background information of the surveyed, such as their sexuality, age, and family permanent residents, etc; 2) the feelings towards the interior thermal and humidity environment in the summertime of the surveyed, such as temperature, wind speed, and dampness, etc. The statistical results are as Figure 14.

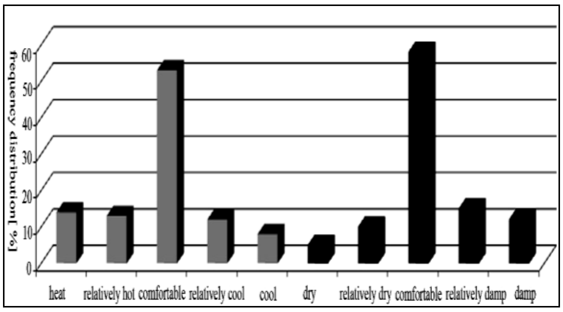


Figure 14: *Statistics of Summer Temperature Comfort and Humidity Comfort*

It can be know from Figure 14, that in the evaluation on temperature, over 70% of residents regard more comfort indoors in the summertime, which indicates that though the summer exterior thermal environment of traditional villages is relatively poor, still residents are satisfied with human settlement. People who think the humidity is moderate take up the largest proportion, which is to tell that though the humidity inside the rural residences in this region is relatively high, yet the local residents are relatively adaptive to the interior humidity in general.

It can be concluded from the above analysis: On the circumstance of no mechanical air-conditioning but only to rely on passive architectural means, it is very difficult to reach the comfort degree required by human body for the residents in this region. In agricultural society, the area where the Hunan region is generally featured with "busy summer and idle winter". People have lower requirements for comfort degree with relatively poor living environment, but their satisfaction degree of human settlement is higher. People create relatively comfortable interior environment in summer by adopting multiple methods, such as increasing the layer height (retaining the hot air above where it is unreachable for people), increasing building density (making use of the shadows among buildings to generate inter-shading to decrease the heat gained by the architecture surface), reducing the area of windows, decreasing the number of windows opened, hanging out the wood sun-shading board (decreasing the heat gained by radiation in summer), and setting up small courtyard (increasing the convection of air), etc. to ensure people's quick physical recovery from heavy work.

5. Conclusions:

From the summertime qualitative analysis, on-site tests and analysis of traditional villages' human settlement in Hunan region, it can be summarized that, traditional village plays a great role in the aspect of composing comfortable human settlement. The main measures in design for reference are as follows:

(1) The general layout distribution featuring low layers and high density of traditional villages is better adaptive to the climate conditions of the high temperature and humidity in the summer of this region. On the one hand, lane-street space with various widths can be formed to promote the ventilation inside the lane ways, and to enhance the human body's thermal comfort; on the other hand, the distance of east-west dwellings can be reduced to form inter-shading, which avoids the problem of west sunshine in this region to create a sound interior environment.

(2) The existence of transitional space can improve the thermal comfort inside the building space. First and foremost, the opening transitional space can effectively bring natural ventilation, which forms sound draughts in dwellings to increase human body's comfort degree; second, transitional space adds one more climate buffer zone between exterior climate and bedroom to increase the climatic gradient, while decrease the exterior climate influence.

(3) Being able to well preserve the heat, traditional dwellings' enclosure structure can effectively increase the delay effect of thermal transmission in summer, decrease the fluctuation amplitude of interior temperature at the same time, and play an obvious role in passive thermal comfort adjustments in summer, meeting the demands of heat prevention in summer. However, the low tightness of traditional dwellings' enclosure structure causes higher interior humidity to a certain extent. The overall tightness of the building can be increased by transforming the enclosure structure, which can further improve traditional villages' comfort degree.

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