

Research on the Improvement Design of Light Environment of Folk Houses in Xingren Ancient Street

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ABSTRACT

Through the field investigation of traditional folk houses in Xingren Ancient Street, it is found that there is insufficient lighting quantity or insufficient lighting uniformity in traditional folk houses. Therefore, through the study of traditional residential lighting methods, combined with the architectural characteristics of the site, while continuing the regional style and features, this design starts from the perspective of architectural space, lighting openings and lighting materials, and proposes strategies for improving the indoor light environment of folk houses in the ancient street, taking Site No. 47 as an example to carry out the design of improving the light environment. It uses actual cases to verify the rationality of the lighting design strategy, with the purpose of helping improve the indoor light environment of traditional folk houses, improving the life quality of residents, providing certain references and suggestions for the improvement of the light environment of traditional folk houses in the ancient street in the future, and also providing a reference for the future development direction of Xingren Ancient Street.

Keywords: Xingren Ancient Street, Traditional folk houses, Light environment, Improvement design.

1. INTRODUCTION

Traditional buildings represent the inheritance techniques of local architectural art and are an important tangible cultural heritage of China. They are distributed in a wide range and are mostly built by villagers in different places, making traditional buildings have the characteristic attributes of regionality and autonomy. Because the main body of the construction is affected by subjective and objective factors, physical environments such as indoor light environment have received less attention, and the problems of insufficient light quantity in traditional folk houses and single lighting openings are issues that need to be resolved urgently. With the development of economy and technology, people's lifestyles and attitudes toward life have also changed, and a large number of new-type folk houses have also appeared; however, most of these folk houses are based on new architectural styles, lacking regional and natural characteristics, and such buildings are highly dependent on construction equipment, which leads to excessive

building energy consumption. At present, in many villages in China, traditional folk houses and new-type folk houses often appear together, so this article collectively refers to them as folk houses, and starts with the study of the improvement of the light environment.

2. INVESTIGATION AND ANALYSIS OF INDOOR AND OUTDOOR LIGHT ENVIRONMENT OF TRADITIONAL FOLK HOUSES IN XINGREN ANCIENT STREET

2.1 General Situation of Traditional Folk Houses in Xingren Ancient Street

Xingren Ancient Street is located in Shangyong Town, Dehua County. It is built on a low terrain surrounded by mountains. The terrain there is high in the west and low in the east, and high in the south and low in the north, belonging to the tableland type. The overall plane of the Xingren Ancient Street is in the form of "one horizontal and

two vertical" layouts, with the street width of 2-3 meters. Due to the terrain, the arcade style buildings in Xingren Ancient Street are the product of the collision between traditional stilt style architecture and the arcade culture of coastal cities. The pillars and beam bodies of the verandah of the arcade are wooden structure, and the inner wall of the verandah of the ground floor is made with boarded doors. The outer wall of the second floor of the arcade is the traditional "pole wall" method, and the back of the arcade still remains the traditional wooden stilt style folk houses in the Dehua mountain area, and according to the changes of the terrain, there are changes of ups and downs [1].

The townhouse arcade is an important feature of the Xingren Ancient Street arcade architecture. The bottom is a gallery frame space, and the second floor is a rectangular wooden verandah. The arcade belongs to a building type with small face width

and long depth, and the townhouse verandah provides important conditions for indoor lighting in folk houses. However, because Dehua County is in the zone of the subtropical monsoon climate, the summer temperature is high and the rainfall is abundant, making the verandah vulnerable to rain erosion. Therefore, the local people have lengthened the cornices of eaves. Although this approach solves the problem of rainwater drainage, it also narrows the upper space of the ancient street, resulting in poor lighting in the street. Due to the unique terrain and overhanging eaves of Xingren Ancient Street, much gray space are created in the street, and it is difficult for natural light to enter. The folk houses on Xingren Ancient Street are dominated by wooden structure. Wood, clay-fired tiles, loam walls and bamboo woven mud walls are the main materials, and the selected wood has a heavier color and is influenced by the architectural characteristics of the arcade, making the indoor lighting problem particularly serious ("Figure 1").

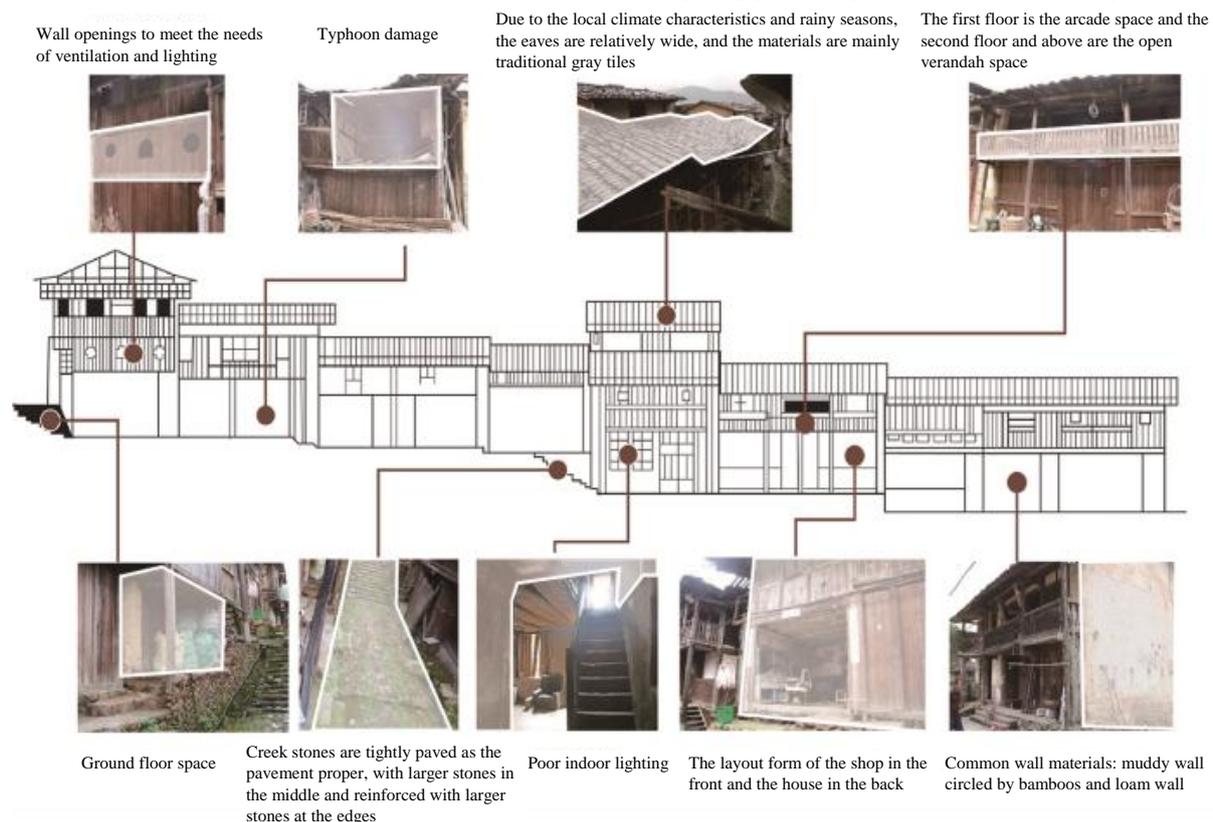


Figure 1 The current situation map of Xingren Ancient Street (revised and drawn by the author).

Xingren Ancient Street was formerly known as "Shangyongyi (上壅驛)", which was an important trading node in ancient times. At that time, dozens of shops were opened here, and the common people operated local specialty, small articles of daily use, cloths, barber shops, inns, etc., and the business

was once prosperous [2]. After years of ups and downs, Xingren Ancient Street has lost its former prosperity. The permanent population loss in the ancient street is very serious, and now only two relatively complete arcade shops remain. Most of the arcades are directly damaged and decay. Some

arcade spaces are constantly changing in order to meet the needs of modern life. For example, some residents directly remove the collapsed wall and connect the arcade building next door to form a larger internal space to meet the needs of life.

2.2 General Situation of Site No. 47

Site No. 47 is located in the southwest of the ancient street, 23 meters long and 17 meters wide. The site includes a collapsed 2-story arcade building with a loam wall remaining, as well as a 2-story arcade building with a verandah and a 1-story building. From the perspective of the relationship between the ground floor shops and the colonnade space, the standard width of the existing arcades in the site is relatively large, and in contrast, the width of the door is small, making it difficult for natural light to enter the interior space. The distance between adjacent houses is small, and the overlap of roofs makes the 1-story building in the site almost always need artificial light to maintain basic lighting. Moreover, the original building has fewer and smaller windows. When the window surface is small, the indoor window is much brighter than the surrounding wall, the wall near the window is very dark, and such a strong contrast will cause glare [3]. In addition to the limitations of lighting

performance, lighting openings and lighting materials are also important factors affecting poor indoor lighting. In terms of lighting openings, existing buildings mainly rely on door openings and rear windows for lighting, and walls are shared between existing buildings, so there is no side window lighting and the natural light source point is very single. And because the existing buildings in the site are solid board doors and solid board windows, the size of the lighting opening is a direct factor that affects the level of indoor light environment, when the doors and windows are fully opened, because the area of the lighting opening is large and there is no other light-transmitting material, this becomes an important light source point [4]. The roof obtains natural light by adding bright tiles, but it is easy to be contaminated with dust and impurities, resulting in low light transmittance, which requires frequent replacement. Because the rafters between the rows are relatively dense and thick, which reduces the light transmittance, with the addition of the barrier of the floor slab, the lighting effect of the lower space is still not good. In terms of lighting materials, the existing interior of the building is composed of clay ground, whitewash, wooden walls and grey tiles, with reflectance of 0.25, 0.75, 0.58 and 0.12-0.32, respectively [5].

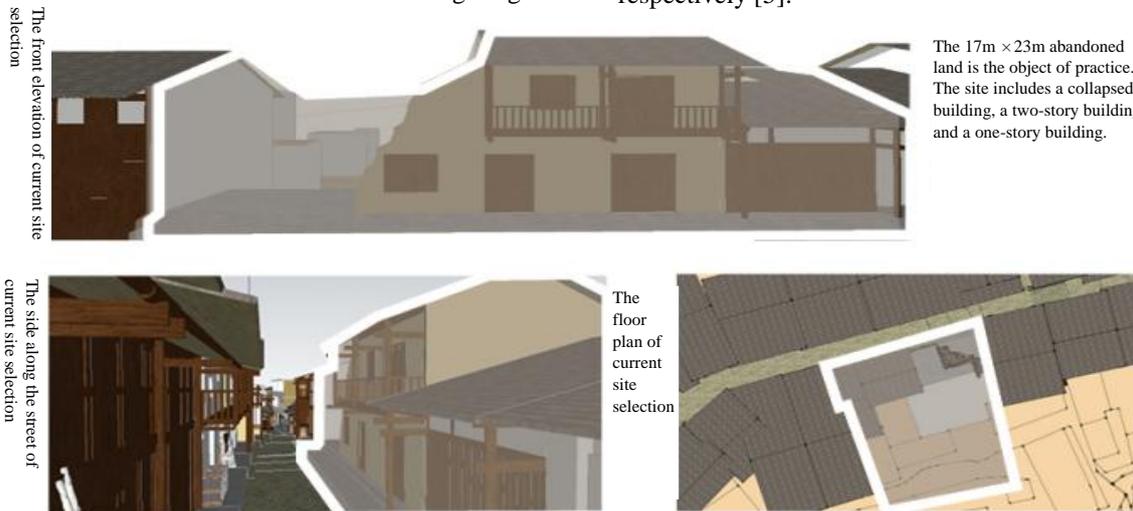


Figure 2 The current situation map of Site No. 47 (drawn by the author).

2.3 Summary of Existing Problems and Design Goals

In summary, due to historical reasons, the indoor physical light of the folk houses on Xingren Ancient Street can no longer meet the living needs of contemporary residents. The existing processing method is mainly to add artificial lighting, and has

not yet improved the spatial structure of the building and the lighting materials. As for the construction of some new-type folk houses that have already been carried out, the existing processing method completely abandons the wisdom of the predecessors in the traditional folk houses, and extensively uses modern lighting technology to destroy the traditional scene of the

ancient street. Combined with site architectural characteristics, this design hopes to choose appropriate solutions based on the study of traditional folk house lighting methods, so as to provide solutions for the improvement of the indoor light environment of folk houses in the ancient street, and also provide certain design ideas for the revitalization of Xingren Ancient Street.

3. STRATEGIES FOR IMPROVING THE LIGHT ENVIRONMENT OF TRADITIONAL FOLK HOUSES IN XINGREN ANCIENT STREET

3.1 The Lighting Improvement Strategy of Spatial Integration

Although there is a common problem of overlapping lighting conditions in traditional folk houses, it is undeniable that there are also some spatial layout forms that are conducive to lighting. Through the analysis of traditional folk house lighting methods, it selects suitable treatment methods for Site No. 56 of Xingren Ancient Street, and uses them after reasonable optimization, so that they can cooperate to improve the light environment of the site. In the research process, it adheres to the principle of strictly abiding by the upper planning, meeting the residential needs and continuing the regional style. The lighting promotion strategy of spatial integration can be discussed from two perspectives of plane and section.

Analyzed from a plane perspective, it firstly carries out promotion of function to meet the basic living needs of residents. On this basis, it combines with local upper planning to inject new functional formats and give the building space a second life; secondly, it opens the originally closed building space, increases the lighting surface, and provides a material basis for introducing natural light into the room. Through the analysis of traditional folk house lighting methods, the plane lighting strategy of setting up verandah, combining patio with hallway, and setting up open inner patio and closed inner patio is more applicable to Site No. 47 of Xingren Ancient Street.

Analyzed from the perspective of section, it mainly increases the lighting surface through the combination of adding, reducing, or changing the space of the building. At the same time, it can also enrich the fun of the space and create more flexible functional spaces to meet the different functional

needs of residents for the space. Through analysis and comparison, the section lighting strategy of utilizing the asymmetric sloping roof, adding reflective interface, setting vertical high and narrow passage, setting outer platform, and adopting internal staggered floor, combination of different number of floors, partial degraded floor and elevated ground floor is more applicable to Site No. 47 of Xingren Ancient Street.

3.2 The Lighting Improvement Strategy of Component Renewal

The author believes that the lighting mode of folk houses can be divided into direct lighting and indirect lighting. Direct lighting is to obtain the light source by opening windows outward; Indirect daylighting refers to the opening of windows to closed spaces, such as corridor space. The size and location of the light intake, as the entrance and exit of indoor light, directly affect the situation of entering indoor light [6]. Under special circumstances, the indoor space of folk houses can not meet the direct contact between the light intake and the outdoor environment, so it can be designed by indirect lighting [7].

In terms of wall lighting, the doors and windows of Xingren Ancient Street folk houses are mainly solid board doors and solid board windows. When they are fully opened, they provide conditions for natural light to enter the room, but when closed, they form an airtight barrier, and the opening and closing procedures of them are relatively complicated. In addition, because of the abundant rainfall in Dehua County, the wooden doors and windows are prone to water ingress and are prone to corrosion and deformation. In order to better solve the problem of light environment, on the one hand, it can keep the original door opening size, choose the door leaf that is easier to open and close, or partially replace it with materials with good light reflectivity.

In terms of roof lighting, Xingren Ancient Street folk houses mainly use bright tiles; especially when the roof truss height is relatively high, there are often several bright tiles on the roof to supplement the indoor light source. In traditional Chinese architecture, bright tiles are generally set in odd numbers, mostly in 3 or 5 rows, and one row consists of 3 tiles. However, bright tiles are easy to stick dust, resulting in reduced lighting, and need to be replaced frequently, and under the shading of rafters, the light transmittance is greatly reduced. If it is possible to increase lighting openings and the

size of openings, or to apply other skylight technologies across areas, while retaining the traditional style, it is also an innovation for the roof lighting technique of Xingren Ancient Street.

4. DESIGNS FOR IMPROVING THE LIGHT ENVIRONMENT OF TRADITIONAL FOLK HOUSES IN XINGREN ANCIENT STREET

4.1 Design Concept

The designing scheme is called peaks over flow shadows, and the idea is derived from the terraced terrain of Xingren Ancient Street. It uses the zigzag skylight that is commonly used in industrial plants across fields, borrows its principles and ingeniously integrates it with the local roof, aiming to let natural light flow in the folk houses through the ups and downs of "peaks". Adhering to the principle of respecting the style and features of traditional folk houses, this case preserves the folk houses in the site and extracts the characteristics of local folk houses. Three new buildings are built in the site to interact with the original ones, and the buildings are enclosed to form a courtyard space. And combined

with the upper planning, it introduces the business form of homestay, in order to attract people to stay in the ancient street, so that the old street can be rejuvenated. This case starts from the perspectives of integrating the plane and section, increasing the lighting surface, and updating the lighting materials, and carries out the design practice for the light environment improvement of Site No. 47 of Xingren Ancient Street.

4.2 Design Practice

When designing the plane space, it is first necessary to carry out functional division as well as primary and secondary classification based on the basic spatial pattern obtained, classify it according to the needs of use, and place rooms with higher utilization in locations with good lighting to achieve optimal use of space. According to the needs of the business form, the plan sets the street-facing building as a public activity area. Other buildings have a more abundant lighting surface, therefore, it sets them as guest rooms and master rooms, and all rooms have access to lighting ("Figure 3").

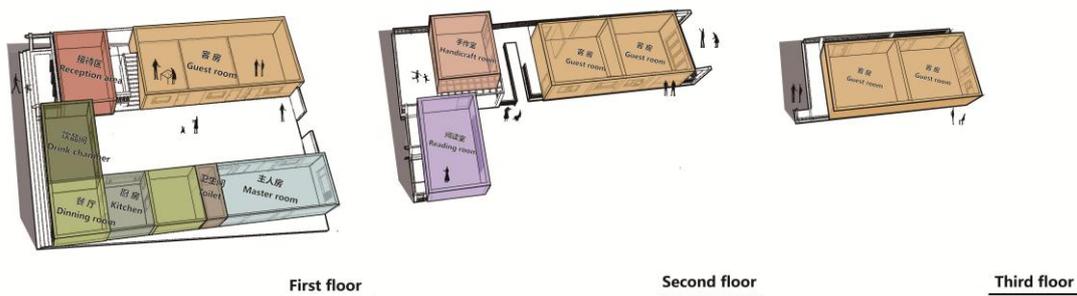


Figure 3 The building functional zoning map (drawn by the author).

In the space layout of the site building, it encloses the patio space through the layout of the building to ensure direct lighting in the surrounding rooms and high lighting efficiency. In the new building, it connects the old and new buildings to form a whole by setting up a semi-open patio space. The patio space not only satisfies the function of outdoor dining, but also greatly increases the lighting rate of the building ("Figure 4"). The townhouse verandah is the characteristic of the arcade building on Xingren Ancient Street, which is not only conducive to the lighting of the folk houses, but also a material carrier for the

harmonious relationship between the local residents. In this case, the verandah of the building inside the site is reserved, and the verandah is used as the connecting carrier of several spaces to form a natural flow line of people ("Figure 5").



Figure 4 The effect picture of the building's open patio space.



Figure 5 The effect picture of the verandah of the building.

When designing the section space, it first breaks through the roof's restrictions on lighting. This case combines the design principle of the zigzag skylight with the traditional roof. The zigzag skylight belongs to a single-sided lighting method, which is characterized by using a sloping roof to reflect light into the room, and the indoor light is stable. In this case, the skylight is set toward the north side; because the diffuse reflection of light can make the indoor temperature fluctuate less, it is very conducive to adjusting the indoor temperature [6]. The height of the vertical opening of the roof in the site and the span of a single sawtooth are set to 0.2, and the tile roof is used, and the slope is selected as 1:1.5 [7]. This approach greatly increases the lighting surface of the indoor space. In addition, in terms of floor design, it adopts the approach of high rear and low front, using the height difference to make the house high in the rear and low in the front to maximize the use of light ("Figure 6"). Besides, it connects the newly built building with the original building on the site, expanding the space on the

first floor, adding windows as a light emitting surface, making the natural light into the drink area on the first floor, and adding lots of windows to ensure the lighting of the first floor ("Figure 7"); What's more, it adds vertical lighting channels in the building as well as verandah outside the building to form a lighting surface; moreover, it arranges the building in staggered floors, realizes the optimal configuration of space, separates the space, and can design lighting openings for the rooms one by one, avoiding a large number of dark rooms. Finally, in view of the lighting problem of the first floor building on the original site, it is positioned as a kitchen in the plan. The original site was a solid wall without lighting conditions; therefore, in this case, by designing the radiation interface, it opens windows on the wall adjacent to the courtyard and sets up a worktop by the window in order to solve the lighting problem.



Figure 6 The effect picture of building roof and verandah.



Figure 7 The effect picture of the drinking bar.

For each interior space, the lighting openings are in the form of direct side windows, indirect side windows and skylights, so that each room has more than two lighting surfaces ("Figure 8"). Since different materials have different reflexivity, in this scheme, it selects suitable materials in different use spaces to maximize natural light. For example, for public activity areas, it uses wooden window frames + hollow doubleglazing (with the visible light transmittance and reflectance ratio of 0.71) as the main materials for lighting openings, the light-colored paint as the indoor reflecting medium (with the absorption coefficient of 0.22, the reflection coefficient of 0.8), and gray floor tiles (with the absorption coefficient of 0.68 and the reflection

coefficient of 0.32); in the bedroom part, plastic steel window frame/wooden window frame + hollow doubleglazing are used as the main materials of the lighting openings. Compared with

before the upgrade, the indoor light distribution is more even, with more lighting openings, and the space utilization of the site can be maximized to meet the needs of the business form.

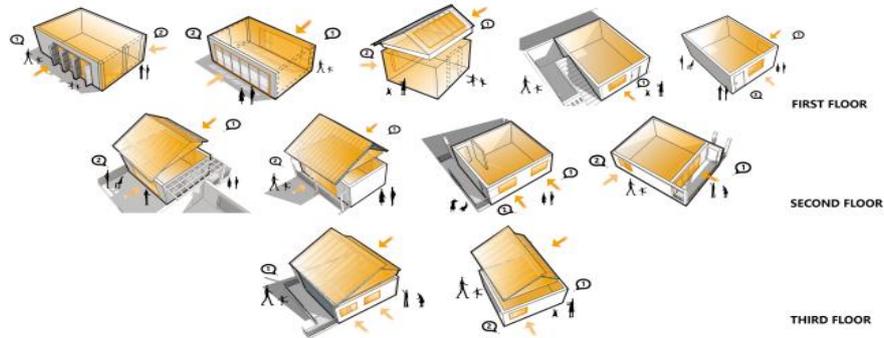


Figure 8 The schematic diagram of lighting in each internal space (drawn by the author).

5. CONCLUSION

At present, the revitalization of Xingren Ancient Street is causing widespread concern from all walks of life, and some folk houses are also spontaneously renovating and transforming their internal spaces. However, due to the constraints of subjective and objective factors, the renovation is mainly based on interior decoration, which has weakened the attention to the lighting problem of folk houses. Therefore, when the folk houses are facing a large number of renovations, this article carries out the improvement design from the perspective of respecting regional characteristics and cross-field combination, aiming to explore new ideas for the lighting upgrading of folk houses and contribute to the cause of revitalizing the ancient street.

AUTHORS' CONTRIBUTIONS

Siying Li designs this study and completes the scheme research and design, and writes the first draft of the paper, Hao Ying guides the scheme design and thesis modification.

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