Green Reconstruction and Economic Analysis of Old Residential Areas in Shanghai

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Abstract. Shanghai has a large number of old residential areas, many of which are made up of "old housing". "Old housing" is very popular in the market because of its geographical location and price advantage. Although the old public housing in the 1980s and 1990s has been more than 30 years ago, it can still be used after transformation. This paper takes the old housing in Shanghai in the 1980s and 1990s as the research object, and carries out green transformation on the thermal performance of its envelope structure, so as to meet the residents' increasing demand for residential ventilation, thermal insulation and other living needs. At the end of the paper, the feasibility of green transformation is analyzed from the economic point of view, and the static payback period of investment is calculated as 17 years according to the cost and electricity saved each year.

Keywords-old houses; thermal performance; green renovation

1. INTRODUCTION

The architecture of our country has developed to the stock age, and the existing architecture has become an important factor affecting the green development of our country. From January to August 2020,27800 old urban areas were newly rebuilt, involving 5.3997 million households. In the 13th Five-Year Plan, Shanghai plans to complete 15 million square meters of old housing and residential comprehensive transformation. From 2016 to the end of last year, Shanghai has implemented a comprehensive renovation of more than 33 million square meters of old housing, benefiting 550000 households.

The old public house in Shanghai was built earlier, not an energy-saving building, and the living environment was poor, among which the biggest problem was the indoor thermal environment. In the early design, there is no too high requirement for the enclosure structure in the hot summer and cold winter area. In the face of the increasing green building standard in our country and the improvement of people's quality of life, the green transformation of the old district has important practical significance.

ICEMME 2022, November 18-20, Nanjing, People's Republic of China

DOI 10.4108/eai.18-11-2022.2327180

2. SHANGHAI'S CLIMATE

Shanghai is a subtropical oceanic monsoon climate, showing obvious monsoon, oceanic climate characteristics. The climate of Shanghai has the characteristics of long winter and summer and short spring and autumn. From June to August, the maximum temperature is more than 40℃, the lowest temperature in winter appears in December or January, the lowest temperature in history is -12.1℃, and the lowest temperature in winter is minus 2-3℃. The climatic characteristics of Shanghai show obvious characteristics of hot summer and cold winter. Before entering summer, yellow plum days, lasting about one month, continuous rain, make people feel sultry, in this period prone to mildew phenomenon. The humidity of Shanghai entering winter is high, and continuous precipitation will occur between December and January, which makes extremely uncomfortable to human body. From the above point of view, Shanghai's climate has the characteristics of hot summer and cold winter and high humidity.

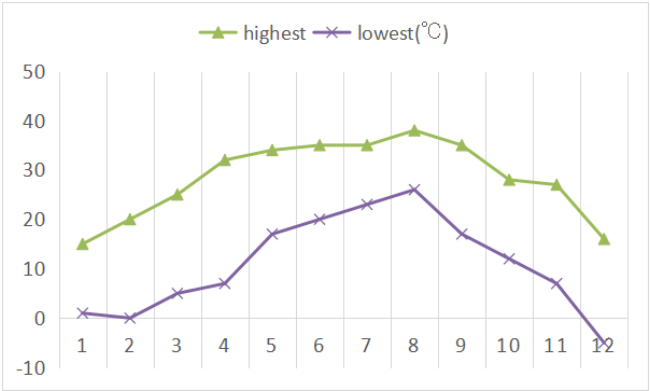

Figure 1 Monthly Temperature Change in Shanghai 2020

3. RESEARCH SCOPE

There are a large number of old residential buildings in Shanghai. These old residential buildings include not only Shikumen, garden houses, but also workers' houses. Most Shikumen and garden houses are historical protected buildings, which are not discussed in this paper. For most people, the old house is more realistic. The old public house refers to the unit welfare house built before the commercial house. The old public house selected in this paper is the old house from 1980s to 1990s. The old public house in this period is more in line with the core family from the household type and area. From the completion time, can continue to use.

4. THE STATUS OF OLD RESIDENTIAL AREAS

Workers' new village is to ease the housing pressure, improve the living environment built by the government and units, now also known as "old house ". Workers' new village began to develop from 1949, until the emergence of commercial housing in the 2000s to withdraw from the historical stage. Among them, the new village developed rapidly in 1952-1954 and 1956-1958. In the 1960s, due to the rupture of Sino-Soviet relations and the slow development of the workers' new village in Shanghai affected by the US-Vietnam War, it was not slowly restored until the 1970s[1].Old residential areas in Shanghai are widely distributed (figure 2), from the inner ring to Central to the suburbs, such as Anshan New Village in Yangpu, Tongji New Village and Pengpu New Village in Laozhabei.

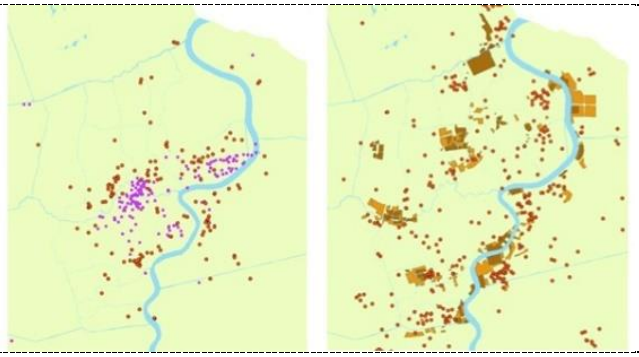

Figure 2 Distribution of Shanghai Old House(Left:1970s Rifht:1990s)

There are two types of old houses, multi-storey and high-rise, which are mainly aimed at multi-layer old public houses. Multi-storey old public house for brick-concrete structure 6 stories, one ladder four or one ladder two households, one floor with small courtyard. The exterior wall adopts solid clay brick, the roof adopts precast reinforced concrete round hole roof slab, the window adopts single layer FRP window [2], the building does not carry on the heat preservation treatment, the insulation performance is poor. In the 80-90s workers in the new village in the one-room, two-room households in the past will be divided into two, three families shared, kitchen and toilet are also shared, with the development of the times, the new village has not seen the phenomenon of sharing, but only a family to live. Shanghai pays more attention to the ecological environment. In the old house district, there are more greening, the main types are house green space and road greening [3].

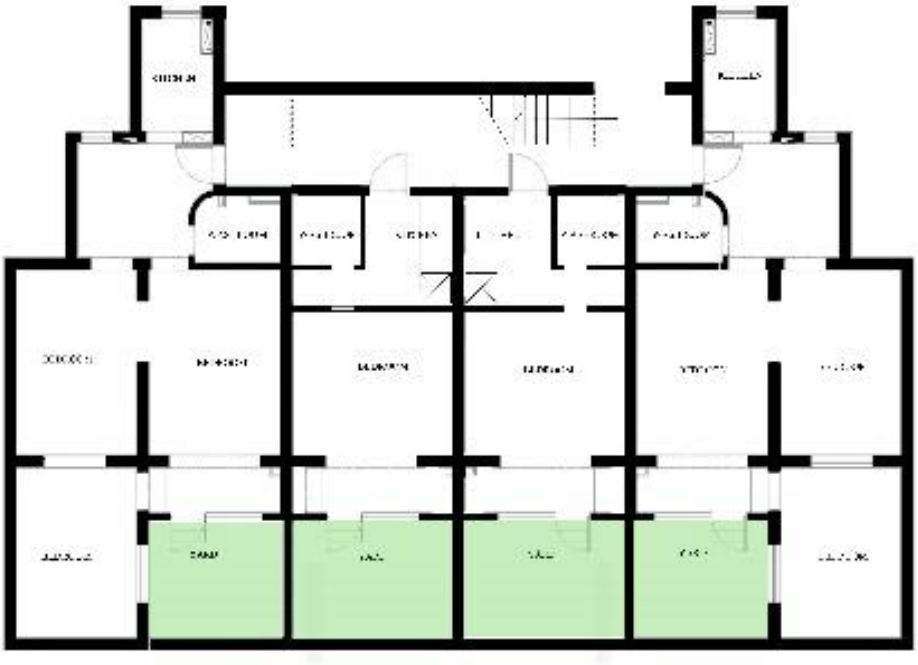

Figure 3 Floor plan

Figure 4 Left: Single-layer FRP windows on the balcony right: old house corridor and iron fence door

5. PROBLEMS IN OLD RESIDENTIAL AREAS

5.1 High humidity

Shanghai's humidity is very large, for the first floor of the house, humidity is the largest, especially when Huang Meitian is easy to dew, resulting in wall and floor moldy.In summer, the humidity is 45-65, Huang Mei Tian can be as high as 80-95, people in Huang Mei Tian always feel the skin is wet, the human body is in a very uncomfortable state.In winter, humidity is generally 60, belong to wet and cold.

5.2 Poor performance of the enclosure

The poor performance of the enclosure structure of the old public house is first reflected in the heat transfer coefficient. The heat transfer coefficient of the exterior wall of Shanghai Laogong House is 2.0 W /㎡· K, the heat transfer coefficient of roof is 1.5 W /㎡· K, and the heat transfer coefficient of window is 6.4 W /㎡· K [5]. The heat transfer coefficient of the roof is 1.0 W /㎡· K (maximum), the heat transfer coefficient of the window is 2.8 W /㎡ ·K.), and the heat transfer coefficient of the window is 2.8The heat transfer coefficient of the enclosure structure of the old house deviates from the standard, especially the heat transfer coefficient of the window. The second is that the stability of the enclosure structure is not high.The large diurnal temperature difference in Shanghai leads to unstable heat transfer and indoor temperature.The third is reflected in the west wall and the east wall. In summer, the west and east walls are exposed to greater solar radiation and higher indoor temperatures.

6. IMPROVEMENT STRATEGIES

6.1 Windows

doors and windows are important nodes for building energy loss. doors and windows can produce 30% energy consumption. doors and windows are also important parts to improve building air tightness. doors and windows mainly lose heat through door frames, window frames, glass, connecting gaps and so on. The entrance door of the old public house in Shanghai is a double door, a wooden door inside and an iron fence outside. Inside the wooden door and door frame has a large gap, not close, easy to leak air. In the transformation of the inside of the wooden door can be replaced separately or the entire door into security doors. There is a yard on the first floor of Shanghai's old house, and the doors and windows here also need attention. The original doors and windows are single-layer FRP windows and single-layer FRP doors, such doors and windows heat transfer coefficient is 6.4 W /㎡ ·K, poor insulation performance, in the transformation can be replaced with hollow layer, vacuum layer or Low-E coated windows, such as Plastic steel low-E hollow Windows. Improve indoor thermal environment, but also use curtains. Curtains can form an air layer between the outer window and the room, the air is a good adiabatic body, can block the summer heat and winter cold. In the curtain can add reflective material, improve solar radiation reflection to the outdoor.

Figure 8 Left: Unmodified window

Figure 9 Modified window

6.2 Roof

The roof is the most exposed to solar radiation, and the top floor house is very hot in summer. There are two main ways to transform the roof, one is to flat change the slope, increase the reflective material, the other is roof greening. The flat slope has been completed in the early transformation.

There are three forms of roof greening: extended, semi-intensive and intensive. Expansion can choose bryophytes and grasses, semi-intensive can choose herbs and shrubs, intensive can be combined with a variety of plants, lawn, shrubs, trees can choose. From the cost and maintenance costs, intensive > semi-intensive > expansion. The thermal insulation effect is intensive (7.497%)> semi-intensive (4.464%)> extended (2.676%)[7].

Because of the deep roots of trees and large shrubs, the required soil layer is thicker and the bearing capacity of the roof is higher. There is no consideration of roof garden in the construction of old house, so the roof bearing capacity can not support the growth of trees. The structure of roof greening is more complex, so it is necessary to set up waterproof layer and drainage layer, which will damage the roof floor greatly. For the old house, more suitable for semi-intensive roof greening.

6.3 External Walls

The improvement of external wall needs to pay attention to three aspects, one is to improve the overall level of heat insulation, the other is to pay attention to the particularity of the east and west walls, and the third is to improve the air tightness.

For the overall thermal insulation performance, external insulation and internal insulation can be adopted, but for the old building transformation should not use internal insulation. Internal insulation will cause damage to the decoration of residents' homes, and is not conducive to the later renovation of residents.Now commonly used external insulation mainly polystyrene particle insulation mortar, polystyrene board, polyurethane, mineral rock cotton, inorganic mortar and other insulation materials. Polystyrene board and polystyrene particle insulation mortar. After the practice of Shanghai in previous years, it is found that if we want to achieve the ideal effect, we need thicker thickness, lower thermal insulation performance, and the polystyrene board is easy to produce cracks in the splicing place, which is not conducive to improving the air tightness of the building. The external insulation system of polyurethane exterior wall and the external insulation system of inorganic insulation mortar were adopted in the reconstruction of Jinyang New Village[8]. The thermal conductivity of polyurethane is small and the thermal resistance is high. The spraying method can be selected in construction, which is helpful to improve the air tightness of the building. Inorganic insulation mortar is easy to construct, but the effect of heat insulation is poor, which can be used at the same time as other external insulation systems.

The maximum temperature of the west wall of Shanghai residential building exceeds 60℃ in summer and 51℃ in winter. According to this situation, the solar radiation of the west wall should be resisted in summer, but the indoor temperature can be increased in winter. Vertical greening has the characteristics of stability. The thermal insulation of east and west walls can adopt vertical greening technology, which not only improves the heat insulation effect, but also increases the greening. Yang He found that in Shanghai area, when vertical greening is

used on different facing walls, its cooling effect is different. In summer, it is sorted as follows: west > east > south to north, and in winter, north > east to west to south. According to Ji Lin's simulation experiment, vertical greening can reduce the annual energy consumption by 2.384%-3.108%.

Improving the air tightness of buildings can greatly improve the effect of heat preservation and heat insulation, reduce energy consumption, and poor air tightness can lead to the increase of building energy consumption. In the old building transformation, can only pay attention to air tightness from the construction aspect. More attention should be paid to the joint of window and exterior wall, parapet and so on. These joints are easy to cause cracks and weaken air tightness.

7. ECONOMIC ANALYSIS

The external Windows will be replaced with low-E hollow Windows made of plastic steel, the external walls will adopt polyurethane insulation system, and the roof and the west wall will be increased with roof greening and vertical greening. The cost of the transformation is 210,300 yuan. After simulation, the electricity consumption can be reduced by 30% every year, that is, the electricity consumption can be saved by 12,000 yuan. Improved the heat preservation performance of residential envelope structure already so, also improved afforestation at the same time, improved outdoor environment, the residence after transformation can reduce the energy consumption of 30%. Natural ventilation during the transition season reduced energy consumption by 20% and extended comfort time by 25%.

8. SUMMARY

Shanghai 80-90's old rooms for one room, two rooms, this layout is very suitable for the current core family use, in the market is also favored. Based on the energy use habits of Shanghai residents, this paper carries on the green transformation to the old house of this era, follows the principle of "passive as the main, active as the auxiliary ", and takes into account the economic problems, and puts forward the reform strategy with high cost-performance ratio. The exterior wall needs to be insulated, and the doors and windows need to be replaced by windows with low heat transfer coefficient, which is the guarantee of building air tightness. For the west wall, east wall and roof, three-dimensional greening can be used to increase the effect of heat preservation and heat insulation, and to improve the problems of sun drying and top floor overheating caused by solar radiation. According to the habits of Shanghai residents and climatic conditions, strengthening natural ventilation can effectively improve the thermal comfort of human body, and the use of natural ventilation and night ventilation can greatly reduce energy consumption and save 12,000 yuan in electricity bills every year.

REFERENCES:

[1] Ye Yaoxian. (2019) Housing Development in China :70 years Urban and Rural Construction 20:6-9.

[2] Ding Xinzhi, Zhu Yibo, Zhu Canyin, Shen Zhiming, Cao Jing. (2019) Practice on Green Transformation of Existing Residential Buildings in Hot Summer and Cold Winter —— Taking Egret New Village as an example. Construction Technology ,12:43-47.
[3] Zhao Yuling, Sun Tongyu. (2020) A Study on Adaptive Strategies for Green Design of Urban Residential Buildings in Shanghai Area 2020 International Conference on Green Building and Building Energy Saving. Qing Dao.24-28.
[4] Xu Peng.(2020). on the Necessity of Southern Heating from the Prevention and Control of Infectious Diseases Building Energy Saving. 48:7-9.
[5] Zhang Xuefeng.(2006)Research on Residential Energy Saving Design in Shanghai- -Energy Saving Structure Design of Outer Guard Structure. TongJi University, Shanghai.
[6] Ji Lin, Zhuang Yu. (2020) Study on Three-dimensional Greening and Residential Energy Consumption and Applicability in Hot Summer and Cold Winter —— A Case Study of Shanghai Architectural skills 07:72-77.
[7] Pan Li, Nie Yue, Yang Jianrong.(2020) A Study on Ventilation Strategy of Shanghai Residential Building Based on Indoor Base Temperature and Refrigeration and Air conditioning 20:39-43.
[8] Lin Xingchun, Ma Suzhen, long Weiding. (2010) Analysis on Energy Saving Transformation of existing Residential Building Enclosure structure in Shanghai. HVAC,40:14-16.