The Investigation and Discussion of Maintenance Situation of old Residences in Shanghai

Fan Liu, Jianwu Pan, and Liang Xu

***Abstract*—There are a huge amount of old residential buildings in Shanghai which involve a large number of residents. With the aging of the buildings, structural or architectural problems are exposed. Therefore, it is necessary to investigate the old residential buildings. This paper collects the data of 34 old residential clusters in three districts of Pudong New Area of Shanghai by means of questionnaire and field survey. It analyzes the causes of the differences in architectural problems of old houses in different regions, different ages and different types of structures. This paper also probes into the causes of structural problems of old residential buildings. And it accumulates important basic data for improving the comprehensive renovation level of old residential buildings and perfecting related laws and regulations in Shanghai.**

***Index Terms*—Shanghai, old residences, maintenance, investigation.**

I. Introduction

Since the establishment of the People´s Republic of China, there have been many old residential districts in cities, towns and villages. With the passage of time, problems have gradually appeared in the old residential districts. These problems are closely related to the lives of residents. Renovation and maintenance of residences has become the theme of many cities and important tasks at the present stage.

We choose three areas in this investigation. They are downtown area A, relatively-developed town B and relatively-developing town C. The investigation concludes 391 buildings with 13661 households built from 1968 to 2003 until August 7th, 2018. The total construction area is 919271 square meters and the investigation still continues. The basic situation is shown in Fig. 1 and Table I.

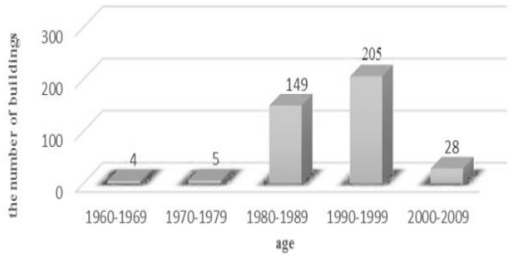

Fig. 1. the number of buildings and age.

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TABLE I: Statistics of Floor Area

Area	Households	Total construction area	Average construction area for each household
A	5243	243349	46.41
B	5046	415548	82.35
C	3372	260375	77.21

Notation: China's per capita floor area is 34 square meters, and each household has more than two residents. By data analysis, the per capita area of the city center is far below the per capita area of our country. The per capita area of township can basically satisfy this mean value.

II. Comparison between Cities and Towns

A. The Difference of Roof Materials among A, B and C

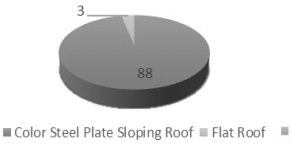

Fig. 2. the roof materials in A.

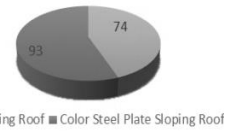

Fig. 3. the roof materials in B.

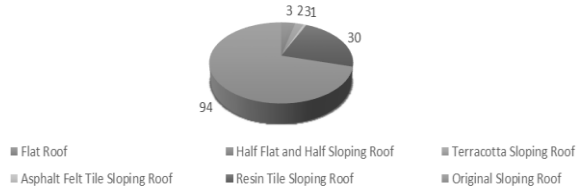

Fig.4. the roof materials in C.

Notation: The main materials of original sloping roof are terracotta and clay tile

Comparing with Fig. 2, Fig. 3 and Fig. 4, it is not difficult to find that the popularity of color steel and resin tiles on sloping roofs in city center A and more developed townships B is very high, but in remote townships C, the usage of color steel is very low, and most of them are still at the level of pottery tiles and clay tiles. The color steel plate has the advantages of light weight, good thermal insulation effect, high flexural strength and high compressive strength. It is convenient to install and time saving. Resin tile has good compressive and impact resistance. It also has good refractory and corrosion resistance. It is adiabatic, soundproofed, energy-efficient and difficult to fade. However, terracotta and clay tile tend to crack and become deformed because of agglomeration. Cracks lead to seepage while expanding. The area of each piece is small. Therefore, it needs more pieces to cover the same roof, which leads to its heavy weight. It tends to be mossy and fall off. Consequently, resin tiles and color steel plate have great

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advantages over traditional tiles. Fig. 5, Fig. 6 and Fig. 7 are some pictures taken on the spot.

Fig. 5. Color steel plate.

Fig. 6. Resin tile.

Fig. 7. Flat roof.

B. The Coverage of Duty Room, Vehicle Shed, Fitness Equipment and Greening in A, B and C

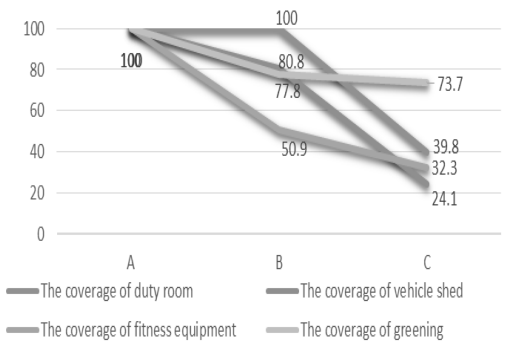

Fig. 8. The coverage of ancillary facilities and greening in A, B and C.

From the Fig. 8, it can be seen that the coverage rate of duty room, vehicle shed, fitness equipment and greening in the urban center is better than that in the township, that is, the ancillary facilities and greening level of the community are positively correlated with the economic development level of the area. Among them, the overall level of greening is high and the difference is not obvious. However, there is a discrepancy in ancillary facilities between cities and towns. Developing towns have more room to upgrade in this respect. Fig. 9-12 are some pictures taken on the spot.

Fig. 9. Duty room.

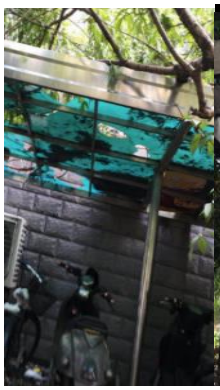

Fig. 10. Vehicle shed.

Fig. 11. Gallery.

Fig. 12. Fitness equipment.

III. Comparison among Different Ages

A. Proportional Distribution of Steel Window and Aluminum Alloy Window in Different Ages

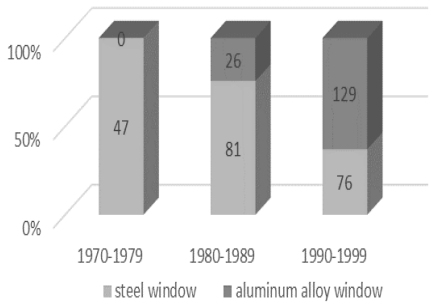

Fig. 13. Utilization rate of steel windows and aluminum windows in different ages.

Notation: Since the data sample size of 1960-1969 and 2000-2009 are too small to describe the change in distribution, it has to be abandoned. Only those with big sample sizes are selected.

According to the Fig. 13, aluminum alloy windows were seldom used before 1980s while steel windows occupied a considerable share of the market. With the passage of time, the utilization rate of aluminum alloy windows gradually increased, and surpassed the steel windows. Correspondingly, the degree of damage to windows is

reduced a lot. The disadvantages of traditional steel windows are poor corrosion resistance, poor air tightness, poor water tightness, high thermal conductivity, and more loss in use. However, aluminum alloy windows have many advantages such as light weight, high strength, good sealing, small deformation , good corrosion resistance and elegant facade, which make them much better than steel windows. Fig. 14 and Fig. 15 are pictures taken on the spot.

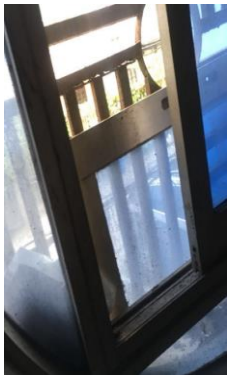

Fig. 14. Aluminum alloy window.

Fig. 15. Steel window.

A. Distribution of Damage to External Façade, Walls and Ceilings of Corridor and Roads in Different Ages

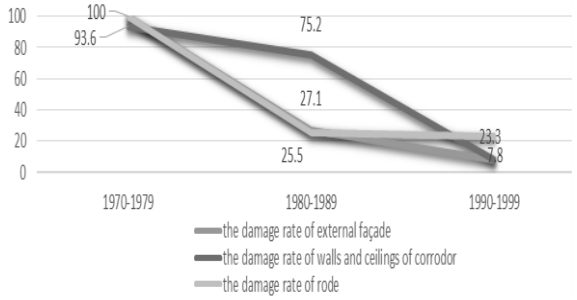

Fig. 16. The damage rate of external façade, walls and ceilings of corridor and roads.

According to Fig. 16, if the residence is newer, the damage rate of external façade, walls, ceilings, and roads is lower. The degree of damage is negatively related to the year of completion of building. This difference in damage is not caused by the difference between urban and suburban, more by the difference in time, so walls and roads are suggested to be maintained and painted regularly. Fig. 17-19 are some pictures taken on the spot.

Fig. 17. External façade. Fig. 18. Wall of corridor. Fig. 19. Road.

IV. Comparison of Different Structures

The structural forms involved in this investigation include the traditional brick-concrete structure, the frame-shear wall structure and relatively rare brick-concrete structure with small beam and thin slab. The comparison among the three structures are in Table II. Fig. 20-24 are some pictures taken on the spot.

TABLE II: The Comparison of Different Structures

Structure	Advantage	Disadvantage
traditional brick-concrete structure	It has good durability. The construction process is simple and it is easy to operate. Its sound insulation performance is good and the cost is low.	The overall stiffness, seismic performance and horizontal load resistance are poor. It is not suitable to be high-rise building or provide large space.
frame-shear wall structure	It has good seismic performance and flexible layout of building space. The lateral stiffness is high. The size of beam and column is small and convenient for construction.	The structural ductility is poor and cannot provide large space.
brick-concrete structure with small beam and thin slab [1]	The cross section of the beam is small, the floor cover is thin and the weight is light. The construction is convenient and quick. The cost is low.	The durability is poor. The precast beam plate is easy to swell and damage, appearing the phenomenon of rusting or protection layer cracking. The end of prefabricated small beam might be loose.

Fig. 20. Brick-concrete. Fig. 21. Frame-shear wall. Fig. 22. Small beam and thin slab.

Fig. 23. Ceiling. Fig. 24. Floor.

V. Summary

A. Architectural Problems

The author believes that architectural problems are related

to the level of economic development and the year of completion of residences.

1) For one thing, the level of supporting facilities and greening in communities varies greatly because of the difference in the level of development. The facilities in developed areas are comparatively complete and the level of greening is relatively high. Less developed areas are deficient in both aspects. For another, different slope materials are used in areas with different economic level, which directly determines the ability of roof waterproofing and rain protection.
2) Because the buildings were constructed in different years, the degree of damage of walls and roads is closely related to it. The external elevation of old residences tend to fall off, the wall of corridors of that are easy to peel and the roads damage more seriously. What' more, the materials used in earlier years for the doors and windows of units were relatively rudimentary and poor in durability. Take the window as an example, the materials used changed from steel to aluminum alloy and nowadays, plastic steel windows are widely used.

B. Structural Problems

The author believes that the main factors affecting the structural safety of older dwellings include internal causes (structural type, defects of design and construction) and external causes (natural and man-made damage).

1) Internal causes

There are many internal factors that affect structural safety including the inherent structural system (such as trabecular plate construction), old design concepts far from current design codes (such as not to consider the seismic measures), construction lacking the constraints of modern building codes and materials with durability problems over time.

2) External causes

a) earthquake

Many low-standard public houses were built in Shanghai between the 1950s and 1980s. Experiments have shown that cracks develop significantly when exposed to an intensity equivalent to 6 degrees. When the earthquake is equivalent to 7 degrees or more, the house is seriously cracked and cannot be used properly until it is repaired and strengthened. Some experts believe that about 60% of the deaths are caused by the collapse of masonry buildings with poor seismic capacity, so improving the ability to withstand earthquakes plays a crucial role [2].

b) Uneven settlement

The foundation in Shanghai is soft soil. Experiments on various types of residential settlement curves in Shanghai have shown that the slope of settlement curve is still upward after completion. That is to say, the settlement still continues slowly, which shows the characteristics of soft foundation in Shanghai [3]. There have been frequent accidents in Shanghai leading to the cracking, inclination and even collapse of old houses caused by uneven settlement. The excavation construction of Shanghai´s Yihong Jingyuan community projection in August 2018 caused the surrounding houses and pavement cracking.

c) Illegal reforming

The illegal adding stories cause the foundation to overload. The removal of vertical load-bearing elements during overrun decoration (load-bearing walls of brick-concrete structures, frame columns of frame structures, etc.) results in progressive collapse [4]. A three-storey building in Songjiang, Shanghai, collapsed because a load-bearing wall was knocked out during renovation in April 12, 2016.

d) Gas explosion

The robustness of old houses is poor, and the progressive collapse caused by explosion is very risky [5] . An old residential building in Xingang Road of Hongkou District in Shanghai, collapsed due to the explosion of a liquefied gas cylinder on May 4, 2014.

VI. Some Thughts on the Strengthening and Renovation of Old Residential Buildings

According to the Measures for the Administration of Residential Special Maintenance Funds, which came into effect on 1 February 2008, various localities have introduced measures to recover the maintenance funds for commercial housing sold earlier. In 2015, 3.983 billion yuan was collected in Shanghai, and the scale of funds collected nationwide exceeded trillion yuan [6]. There are many old residential areas and shops along the street external elevation renovation. Although after the project, the buildings acquire a completely new outlook and the performance of the house such as leak-proof, secondary water supply or drainage layout has been greatly improved, these works have not improved the structural safety of the house [7].

The construction area of completed and to be completed buildings in China has reached 70 billion square meters [8]. A significant proportion are old residences, some of which have even exceeded their designed useful life. It is virtually impossible for them to be completely demolished and rebuilt in the future, and only through c and renovation measures can they gradually meet the requirements of the code standards. So, where does the money come from? Who's going to strengthen it? How to strengthen it? This is the three main problems that must be solved. First of all, it is necessary to carry out a diversified study on the sources of funds for strengthening projects. Secondly, some researchers proposed to guide real estate companies and construction teams to carry out business transformation, not only to curb the overheated development of the new construction market, but also to enhance the living experience of existing buildings and prevent social stability problems caused by the bubble of the real estate economy [7]. Finally, at the legal level, it is necessary to improve the policies and regulations for the identification and strengthening of old residential buildings, and at the technical level, the relevant code rules should be perfected. This problem needs the coordination and cooperation of government management, building planning, economic finance, civil engineering and many other disciplines and departments to be properly solved.

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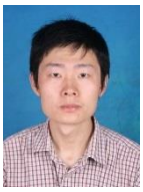

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