Research on Maintainability and Renewability of SI Housing

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Abstract: Based on the development status and construction technology of SI residential buildings in developed countries and China, this paper focuses on the technical design method of maintainability and renewal of industrial residential buildings. The paper points out that it is the partial production and integrated assembly technology of industrial construction that make the future maintenance and update of housing products possible. The scale of industrial operation will change the structural form of the construction industry chain to a large extent, which is of great significance to the development of Chinese housing industrialization.

1. introduction
SI house is the main architectural form of modern industrialized house. The development of SI housing system in different countries has its own advantages and disadvantages, and the developed countries are represented by the Netherlands and Japan. Based on the development status and early renovation cases of Holland and Japan, as well as the construction situation and development advantages of CSI housing in China, this paper will deeply study the maintainable renewal nature of industrial residential buildings.

At present, most of the domestic industrialized residential buildings still pay attention to design and construction, and there are few special studies on its maintenance and renewal. Housing can be the purpose of maintenance updates, prolong the service life of residential products in SI house assembly of building maintenance updates can also be in the industrialization level further improving the quality of residential products to improve living conditions, better adapt to the development of green building, and can adapt to a wide range of social needs, this building to promote the industrialization development will play a more important role in [1]. At present, there is still a serious lack of recognition of this situation in the SI house market, and the maintainability and renewal of industrial residential buildings have not received due attention.

Since the 18th National Congress of the Communist Party of China, the implementation of construction industrialization and the development of green buildings have become an important agenda of national construction and development, and the requirement of "100-year residence" has thus emerged [2]. In the case of SI houses, this can be achieved by making them maintainable and updated, this is the significance of this study.
2. Concepts and features of SI housing system

2.1. Western SI housing system and its early renovation and renewal

Holland and Japan are the representative pioneers of western construction industrialization. In the early 1960s, the Dutch architect famous professor John. Habraken puts forward the theory of SAR to Support the body, the theory for the first time put forward the design and construction of the residence is divided into two parts, the residential development as the main structure to Support body S (Support), will develop the load bearing part of filling body part I (Infill), which is the source of the SI residential theory [3]. The core content of the design concept of SI house is to design and construct support body S and filling body I respectively. The supporting body S is constructed through on-site casting, and the filling body I is transported to the site for assembly after standardized production in the factory [4]. This can obviously reduce the amount of wet work, improve work efficiency, and reduce the pollution to the environment.

On this basis, in the 1970s, professor Habraken puts forward the OB (Open Building) Open architecture theory, the theory emphasizes the residential design and construction work Open to the public, society and environment, thus creating a flexible rich residential, increasing the sustainability of housing, and therefore is considered to be the basic theory of the residential industrialization and [5].

![Figure 1: The Matura Infill Systems](image)

It can be said that the SAR support housing theory and the OB open building theory not only created the construction concept of the contemporary SI housing system, but also the concept cradle of the diverse design of the filling body and the maintenance and renewal of the industrial housing. In the early residential renovation in the West, such as the Wahlberg residential renovation project in the Netherlands in the early 1990s, the project team used the open building theory and the latest technology to remove all the filling body of the original house, and only the supporting body was retained. At the same time, steel frame technology is adopted for reinforcement, and necessary openings of doors and Windows are opened on the structural walls according to user requirements [6]. Finally, the Matura Infill Systems were boldly applied internally, which greatly improved the installation efficiency and applicability of the filling body (Figure 1). Wahlberg residential district renewal projects in a short time and complex under the reality conditions of completed the update of the old house, is a use only original architecture, are all made of new type filling restructuring built update successful cases and the modernism of the facade style and built-in system and economic suitability for this update reconstruction has won a wide range of social praise (Figure 2). The project
takes advantage of the adaptability of Filled Volume I to become a practical example of early residential renewal.

As a developed country in SI housing construction, Japan put forward the characteristic KSI housing theory (Kikou Skeleton Infill, SI housing developed by Japanese urban institutions) at the end of last century, and gradually formed the KSI housing system [7]. This system has two important characteristics. One is to separate the design and construction of the Support and the filling body in a real sense. The Support part emphasizes the durability of the main structure to meet the construction requirements of the longevity of the building. The second is to give full play to the advantages of public participation in OB open building, so the design of its filling body I has strong adaptability to meet the diverse and flexible needs of residents. For example, the renovation project of Qinzhi County Housing in the beginning of this century has three main features. First, the old residential structure is retained and strengthened, and all its internal fixtures are removed. On this basis, the modern "variable filling body system" is boldly used (Figure 3). Second, shear walls are set intensively to ensure the bearing capacity of the structure and the integrity of the internal space, and the layout is reorganized in consideration of the needs of residents [8]. Third, we should give greater consideration to economic benefits and social and cultural inheritance. The project is a collection of new modern socialist construction idea, the historic context, applicability and economic rationality is a body high technology and fusion style building reconstruction of the update, its features of habitable praised by people, its outstanding mottled old brick wall with a side a new high-rise buildings set each other off, make the person feel historical massiness, affairs of human life vicissitudes of life, and feel the updated construction life force. The project is a good demonstration of the concept of industrial residential buildings in terms of maintenance and renewal.
2.2. CSI Housing System in China

China put forward the concept of CSI housing (China SI) in 2006, forming a new industrial housing construction system with Chinese characteristics. The main feature of CSI housing system is: according to the partition standard of housing support S part and housing filler I part, the housing filler is decompressed into various components, and the standard chemical plant production. The standardization of part components makes the on-site assembly and construction more convenient and easy, and can solve the problems such as excessive consumables, high energy consumption, heavy pollution and waste of secondary decoration in current residential construction in China. The important feature of CSI residential filling body is standardized design, and it has advantages in terms of adaptability and variability [9].

It should be particularly pointed out that China began to implement the strategy of "Centennial Housing in China" in 2012. The strategy is based on the CSI housing system, and according to the concept of sustainable construction and development, it coordinates the integrated technologies of planning, design, production, construction and operation and maintenance throughout the whole life cycle of the housing, aiming at building a new industrial housing with long life, good quality and green and sustainable performance. Strategy of "Chinese one hundred residential" integrated integration technology between the large space structure, the house, within the external wall thermal insulation, dry floor heating, ventilation in an all-round way and whole sanitary ware, integral kitchen, pipeline and so on many technology, obtained the rapid development in recent years, Shanghai William mansion 11 floor (Figure 4) and Jinan "the home of tomorrow ii project is among the more typical case of success.
In the middle of the last century, in order to solve the problem of surging demand for housing, China also used industrial construction technology (assembly construction method) to build a large number of plate residential buildings, and at that time, to a certain extent, played a role in relieving distress.

By the turn of the century, these old houses were basically demolished in the surge of urban demolition and construction, and even no cases of renovation were left. In fact, most of these slab housing structures are intact and still have a certain service life. In today's rapid development of industrial housing construction, this further highlights the importance of its maintenance and renewal. In jietan sigh, we also feel deeply current party central committee advocates green development concept again and again, build "resource economize" and "environment friendly" the important meaning of society. This is also the purpose of this paper.

3. SI House is maintainable and updated with significance

3.1. Proposal of maintainability and renewal of industrial housing in China

SI house construction is an important way to realize green development in China. Compared with traditional housing, the unique standardized design, component production and integrated assembly technology of industrial construction may maintain and update residential products at the industrialization level. This maintainable and updated function is of great significance to realize the requirements of building longevity and good quality of the national “Centennial residence”. As is known to all, the renovation and reconstruction of traditional residential buildings are usually completed or mostly dismantled, or renovated and expanded, resulting in a huge amount of work and a serious waste of resources [10]. The renovation of traditional residential buildings characterized by resource consumption obviously does not meet the requirements of Chinese green development and Centennial residence system, nor can it cope with a large range of social needs. For industrial residential buildings, people can only upgrade and improve the housing function conditions of the eager expectations placed in its maintenance and renewal. Modern construction technologies such as
standardized design, factory production and assembly construction of industrial residential products provide feasibility for the maintenance and renewal of such buildings, and also provide possibility for the resource intensification and industrialization operation of the maintenance and renewal.

With the continuous improvement of residents' living standards in recent years, people's requirements for improving living conditions, enhancing residential functions and livability are also increasing. In addition to the limited adjustment function of market transactions, can people's demand for higher housing conditions be met by new housing? For our country, which is relatively deficient in resources, it is obviously unrealistic to do so. Therefore, people naturally turn their attention to the maintenance and renewal of residential buildings, hoping to improve living conditions. With the increasing proportion of industrial residential buildings, residents' demand and eager expectation for this kind of maintenance and renewal with the purpose of improving their living conditions will also increase day by day.

3.2. The trend of industrialization development that industrial housing can be maintained and updated in China

The standardized component design and factory production of industrial residential products not only have the advantages of green construction, but also have the functions of maintaining and improving due to the maintainable and updated nature of assembly construction. However, this advantage has not been properly developed at present.

The maintainable renewal of industrial housing will no longer be only the maintenance and replacement of parts of the components, and its overall promotion of living conditions should be paid more attention to and developed. Through component design and assembly integration technology, industrial residential buildings have a high degree of convenience in maintenance and update [11]. From the perspective of society, the increasing user demand will promote the further development of the maintenance and renewal of industrial housing, and then form and reach the scale of industrial operation. This scale effect is of great significance to the development of residential industrialization in China. 1) From a visual perspective, it can effectively improve people's living conditions and enhance the livability of residential products; 2) This major change in turn promotes the whole construction industry chain to respond. From the beginning of design, including production, manufacturing, construction and assembly, the functional design of components will be further emphasized to improve their maintainability and renewal; 3) Finally, the huge social demand generated by maintenance and renewal will make the industrialization operation and the whole construction process form an interrelated and interdependent relationship, and will eventually form a new industrial chain of Chinese industrial housing construction. The industrial chain will include design, manufacturing, assembly, maintenance and update and other links, and form a unified production, supply and marketing cooperation to build a community. The formation of this new industrial chain and the construction and development mode of cooperative community will further improve the quality and performance guarantee of Chinese SI house, which is of great significance to the industrialization development of Chinese housing.

4. Conclusion

Through the research on the construction technology of industrial residential buildings at home and abroad, the paper shows that it is the standardized design, part production and integrated assembly technology of industrial construction, to make the maintenance of residential products update large-scale operation possible. The purpose of the maintenance and renewal of industrialized residential buildings is not only to prolong the service life of residential products, but also to further improve the quality of residential products, improve living conditions and better adapt to the wider social needs, this will play an important role in promoting the development of Chinese housing industrialization, but also for the green and sustainable development of Chinese construction industry.

This paper first introduces the concept of SI housing, and through the early housing renovation projects in the Netherlands and Japan, as well as Chinese CSI housing system and other cases,
in-depth study of the SI housing maintainability and renewal nature. The paper also analyzes and studies the housing industrialization and Chinese “Centennial residence” system, and concludes that it is the standardized design, part production and assembly construction of the internal components of the SI housing, the maintenance and renewal of SI housing products can realize the scale of industrial operation.

This paper further studies the function and market acceptance of Si residence, and discusses the necessity of maintaining and renewing SI residence, considering that it is urgent to improve the market recognition and after-sale operation management level of industrialized housing products, and that the maintenance and renewal of housing is not only the necessary guarantee for prolonging the service life of housing, but also the realization of 100-year housing, it is also an inevitable requirement to realize low-carbon, environmental protection and green development of housing construction. This paper analyzes the main problems existing in the development of housing industrialization in our country at present, and puts forward that we should strengthen the research on the maintainability and renewal of the industrialized housing products at present, and promote its industrialization operation scale, finally, it can form a new type of industrial chain of design, manufacture, assembly, maintenance and renewal of the whole life cycle quality and performance guarantee, which should be the inevitable requirement of the further development of our country’s housing industrialization. This is the innovative thinking in the development concept of housing industrialization in China, and also illustrates the social significance and economic value of this study.

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