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Research on Prefabricated Interior Renovation of Existing Buildings

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Abstract: Requirements for the quality of housing have been increasing in recent years. Many existing buildings can no longer meet the needs of residents due to functional, layout, and other issues, and need to be renovated. However, traditional renovation methods have problems such as high pollution and high consumption. With the rapid development of prefabricated construction and green environmental protection concepts, the problems of traditional interior renovation can be resolved using prefabricated interior decoration. As a new and advanced method of renovation, prefabricated renovation reduces construction segments, workload, pollution, and waste, and it promotes the upgrading of the traditional renovation industry.

Keywords: Existing buildings; Prefabricated building; Wet construction; Dry construction

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1. Status and pain points of renovation of existing buildings

1.1. Necessity of renovation

Most existing buildings have many problems as they age, and they are gradually becoming unable to meet the requirements of residents. Some even have significant safety hazards. Therefore, it is necessary to renovate existing buildings.

Firstly, the current needs of users far exceed the functional scope of existing buildings. For example, the layout design is inappropriate: the total area is small, especially the kitchens and bathrooms are too small, and some layouts do not have independent functional spaces such as bathrooms, entrances, workspaces, and storage. The overall interior space is enclosed, with poor lighting and ventilation, with limited functions.

Secondly, because some buildings were constructed a long time ago, their building performance is poor, and there are problems like aging and disorganized pipelines, which lead to significant safety hazards. The doors and windows are aging, and the interior insulation and airtightness have deteriorated. The drainage pipelines are easily blocked due to overwashing, and because of poor ventilation, there are serious odors. The problems of gas and heating supply are difficult to solve, in which the circuit load is small and cannot meet the requirements of many electrical appliances being used together.

1.2. Pain points of renovation

1.2.1. Huge time and energy investment

Unlike new residential renovations, the renovation of existing will affect the daily lives of the residents, and they will need to temporarily move out. The renovation process is difficult to control, and there may be problems such as delayed construction progress, which requires homeowners to spend a lot of energy

and time, resulting in indirect cost increases.

1.2.2. Renovation safety hazards

Space reorganization will usually be carried out in the renovation of existing buildings, and walls are the basic components of the building structure. Due to the lack of understanding of the building by the homeowner or construction personnel, the structural safety of the building is at risk. In addition, aging wiring can also cause fire hazards during the construction process.

1.2.3. Environmental and noise pollution

The process of dismantling and renovating old structures is noisy, which will cause noise pollution to neighbors and the surrounding environment. Moreover, the construction waste generated while dismantling and renovating can also cause pollution to the nearby environment.

1.2.4. Unstable renovation quality

There may be some problems that are difficult to solve thoroughly even with renovation, such as rusting water pipes, peeling off of electric wire insulation layers, and damp walls. If these problems are not well resolved, they will reappear as time goes by.

1.2.5. Material selection and storage

Most of the buildings renovated are located in residential areas, and the old communities have limited space for material storage and transportation. Secondly, homeowners generally do not understand the characteristics of the materials used in the renovation. Therefore, the selected materials for renovation might interfere with the existing material, making the effect of renovation less ideal.

2. Comparison of traditional interior decoration and modular interior decoration

2.1. Disadvantages of traditional renovation methods

The traditional wet-work construction method has been popular in China for many years, and the traditional "guerrilla-style" renovation method involves complex construction processes, long construction periods, difficulties in ensuring quality, and over-reliance on manual construction methods. Additionally, the traditional decoration process has caused a series of problems that make industry regulation difficult, such as environmental pollution, noise pollution, and the use of substandard materials. In summary, the disadvantages of traditional decoration are mainly manifested in the aspects below.

2.1.1. Poor workmanship

Quality problems have long been present in traditional renovation, such as floor water seepage, hollowing and cracking of waterproof layers in bathrooms, various leaks caused by different reasons, uneven floors, and accumulation of salt on tiled surfaces. In kitchens, tiles may fall off, pipes may break, and large cracks may appear due to dimensional errors during installation. In addition, other indoor rooms are also prone to problems such as moldy walls, damp and crumbling walls, ceilings deforming, peeling or falling off, uneven floors or floor joints, and floor pipeline failures. The level of workmanship of construction workers, the quality of materials and equipment used during construction, the weather and site conditions during construction, and other factors all affect the final quality of the completed project. Due to the multitude of factors that can influence the quality of construction, it is difficult to control and ensure quality in traditional renovation.

2.1.2. Labor shortage and low construction efficiency

The labor force is shrinking steadily as China's birth rate continues to decline, and the demographic dividend is gradually disappearing. The construction industry is inherently labor-intensive, and the new generation is less willing to enter this industry, while the existing young labor force is also gradually leaving. Moreover, the traditional interior renovation industry has a long industrial chain, with a large amount of labor required for the manufacturing and design of materials in the early stages, as well as the construction and maintenance services in the middle and later stages. Nowadays, systematic training is also needed for these kinds of jobs. In traditional construction, most of the work is done manually, and the materials and methods need to be compatible with the original material used in the building. In addition, the construction efficiency is also very low due to factors such as weather and temperature, which may delay construction time (**Figure 1**).

Figure 1. On-site cutting

2.1.3. Safety hazards during the decoration process

During the construction process, due to on-site operations and the lengthy and complex procedures, there may be violations such as the unauthorized use of electrical welding tools and open flames, and the arbitrary placement of flammable materials and construction waste can lead to fires and other dangers. For example, workers smoking at the construction site, cooking with fire, or violating electrical usage regulations by private wiring, overloading electricity, and so on (**Figure 2**). In addition to electrical safety, during the renovation process, the openings and grooves in the wall may cause certain damage to the building structure, which could potentially lead to safety issues such as building collapse.

Figure 2. Violation of electricity regulations

2.1.4. Health and environmental pollution

Because the parts for renovation are made on site, the materials and techniques used are subject to significant limitations, leading to indoor environmental pollution and renovation waste pollution.

Indoor environmental pollution is mainly caused by the extensive use of chemical agents such as latex paint, oil paint, and adhesives, which results in indoor air pollution that dissipates extremely slowly. According to a survey by China Indoor Environmental Monitoring Center, air pollution caused by renovations leads to 111,000 deaths each year in China, with 800,000 to 1.2 million children born with congenital disabilities.

The waste generated during the renovation process is also a significant factor in environmental pollution. If the waste is discarded indiscriminately, it will pollute the soil and be difficult to degrade. When it is left in public places for a long time, the volatile chemicals emitted from it can harm people's health (**Figure 3**).

Figure 3. Dust pollution

2.1.5. Excessive resource wastage

The main cause of excessive resource wastage is mainly due to "secondary renovation". "Secondary decoration" refers to the removal of interior renovations by homeowners after purchasing a pre-decorated or second-hand house due to dissatisfaction. Most homeowners remove the floor tiles, walls, and sanitary ware after buying a new house, resulting in the rampant phenomenon of "smashing and replacing," leading to a large amount of resource wastage and environmental pollution.

2.2. Concept of prefabricated interior renovation

2.2.1. Dry assembly

Reliable support and connection structures are achieved through anchor bolts, structural adhesives, supports, etc., making the construction process relatively fast.

2.2.2. Separation of pipelines and structures

Pipelines are set outside the structural system and buried in the cavity between the structure and surface layer.

2.2.3. Integrated customization of parts

The renovation parts are integrated and customized and produced in a factory. Through on-site measurement and data collection, various standard and non-standard parts are centrally produced in the factory.

2.3. Advantages of prefabricated construction

2.3.1. Reduction in material waste

By utilizing building information modelling to simulate construction scenarios during the design stage, material waste can be reduced from the outset. Prefabricated parts and components are industrialized and produced in factories, eliminating the need for on-site processing and ensuring that all materials are utilized with minimal waste during construction.

2.3.2. Reduced construction time

Traditional renovation methods require over 20 workers from different trades and a construction period of 30 to 40 days. In contrast, prefabricated construction technology only requires four workers and can be completed in six days, significantly reducing construction time.

2.3.3. Improved quality

All installed parts are quantitatively produced by factories, ensuring the quality and performance of each part. There is no need to rely on workers' experience and expertise to create the parts on site, and the use of wet construction methods is avoided, thus ensuring the overall construction quality from the parts to the final product.

2.3.4. Increased construction efficiency

Traditional construction requires over 20 construction procedures, including water and electricity installation, waterproofing, and tiling, which can be time-consuming and laborious. Prefabricated construction simplifies on-site construction procedures by centralizing production in factories, with installation being the only on-site process. In this way, construction efficiency can be improved significantly.

2.3.5. Health and environmental benefits

Prefabricated construction materials are selected based on their characteristics, such as waterproofing, fire resistance, and durability, and materials such as bamboo fiber and aluminum alloys that do not contain harmful chemical components are used. The use of chemical reagents like adhesives and glue is avoided by replacing them with joint assembly, thus significantly reducing the release of harmful gases such as formaldehyde. This ensures a clean, pollution-free, and noise-free construction environment that is safe, environmentally friendly, and healthy.

2.3.6. Convenient post-maintenance

In prefabricated construction, pipelines and the main structure are separated, and standardized parts and components are used, which are designed with post-replacement and maintenance in mind, making maintenance easier and more convenient.

2.3.7. Reduces resource waste in secondary renovation

Modular interior decoration is independent of the main structure, allowing for flexible and adaptable indoor spaces without generating waste or affecting the building's lifespan. In this way, the building's lifespan can be extended while accommodating different needs for different demographics.

2.3.8. Facilitates supervision

Due to the centralized and quantifiable production in factories, quality checks can be conducted throughout the production of parts and components, making the process transparent and easier to supervise. In this way,

the quality of the parts can be ensured compared to traditional methods that relies on manual labor.

3. Renovation ideas for existing buildings

Different from traditional decoration methods, prefabricated interior renovation can fully realize the design concept in the project. By analyzing the pain points in renovating existing buildings, the principles and ideas for modular interior decoration is more focused on synergy, new technology, and humanization.

3.1. High synergistic effect

Renovating existing buildings involves many issues, such as building structure, heating, water supply, electricity, air conditioning, and more, due to prolonged usage and mismatched user needs. The process of prefabricated interior renovation should be synchronous and coherent, with the user's needs and problems as the main concern. The data and details of the building that is to be renovated can be integrated into the building information modelling system, and the overall coordination in the design, production, and installation stages can be carried out, ensuring efficient and synchronous renovation.

3.2. New technology

Problems such as aging pipelines and reduced structural stability are prevalent in existing buildings. The old method of pipeline renewal and renovation through wall slots is no longer suitable. Protecting the stability and load capacity of the building structure is the focus of modular interior renovation. Therefore separating the wall and pipeline using new technologies can best protect the safety and stability of the existing building structure. Additionally, the high flexibility of construction technology can ensure easy maintenance and upgrading, thereby reducing costs.

3.3. Humanization

Since the buildings are going to be used for a long time, the changes in the users and their ages should be considered during renovation. The users who will occupy the room after renovation should be identified and reasonable adjustments should be made to the indoor space according to the needs of the users. In particular, for key indoor spaces such as bathrooms, kitchens, and bedrooms, intelligent and age-appropriate designs should be made to meet user needs.

Furthermore, indoor spaces should consider possible changes in personnel within the user's family over time, and prefabricated wall structures can be used to flexibly divide and combine spaces, ensuring that the renovation can meet user needs in the long term.

4. Applications of prefabrication technology

4.1. Wall engineering

Prefabricated walls are installed by first placing a framework of metal studs and tracks, and then embedding pipes and wires into the wall cavities. The cavities are then filled with rock wool or fiberglass insulation for soundproofing and fire resistance. Lastly, decorative panels are attached to the studs with connectors to complete the installation (**Figure 4**).

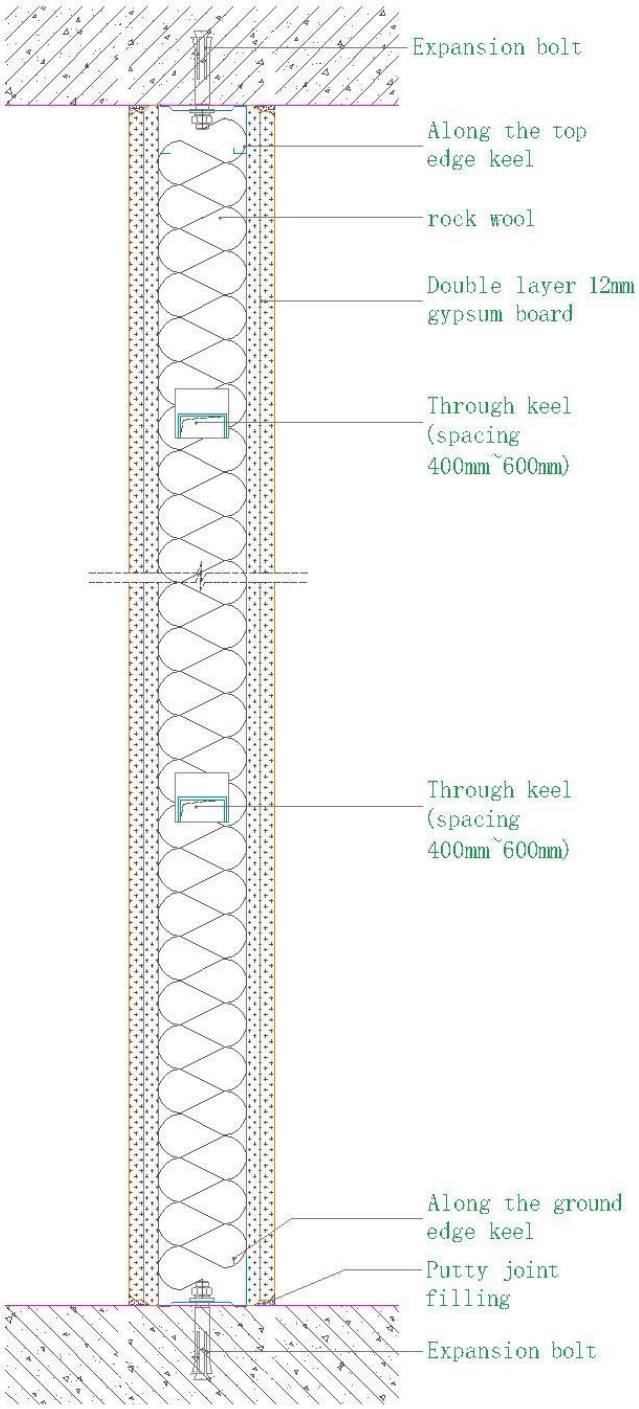

Figure 4. Prefabricated wall

Many wet construction procedures such as wall grooving, leveling, and wallpaper pasting can be eliminated through using prefabricated walls. Besides, environmental and noise pollution can also be reduced, and dry construction can reduce workload and improve construction quality. Prefabricated walls can also be quickly disassembled and modified in future upgrading and maintenance processes.

4.2. Ground engineering

In prefabricated floors, adjustable metal supports are used to suspend the base plate and form a suspended floor module. Then, insulation floor modules, underfloor heating pipe modules, followed by decorative

surface layers are installed (**Figure 5**).

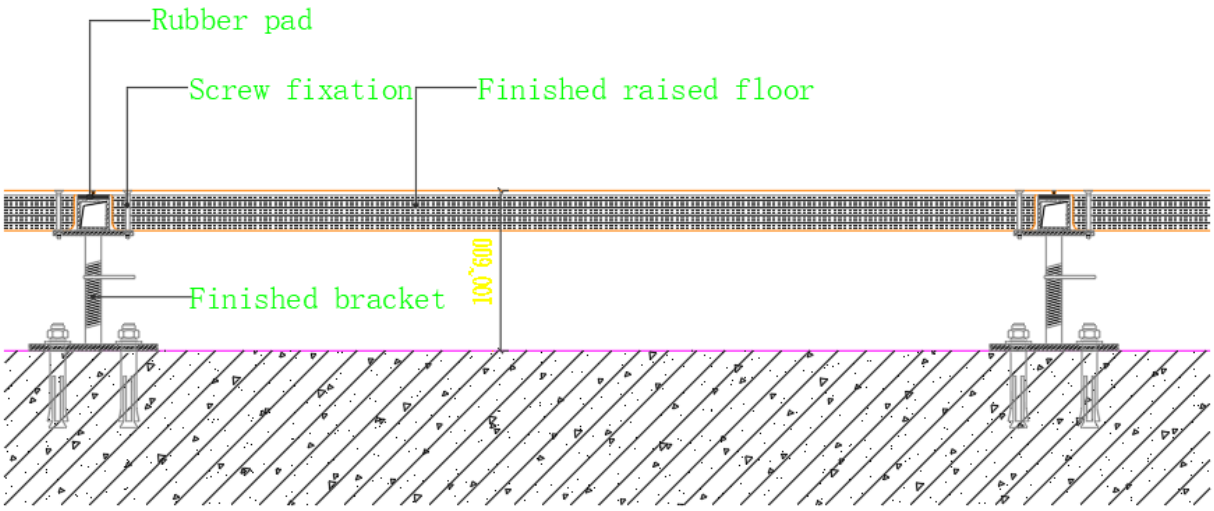

Figure 5. Prefabricated floor

Prefabricated floor systems can reduce traditional construction methods such as leveling and avoid wet construction. The height of the floor can also be controlled, and electrical and plumbing lines can be routed through the space formed by the raised floor, separating them from the original structure. The prefabricated floor system improves construction efficiency and quality, and also ensures the effectiveness of underfloor heating.

4.3. Integrated kitchen and bathroom

The integrated kitchen and bathroom system integrates the wall structure, materials, water and electricity pipelines, and furniture of the kitchen and bathroom through reasonable planning. The prefabricated components such as wall panels, floor panels, and cabinets produced in the factory are assembled through modular construction. In the construction of the integrated kitchen and bathroom system, an integrated waterproof base is made, and cabinets are mounted on the wall, and the pipeline structure is separated from the structure, resulting in good waterproof effect, easier maintenance and replacement, and improved efficiency of the kitchen and bathroom space.

5. Conclusion

Prefabricated interior renovation has the advantages of being environmentally friendly, high quality, efficient, flexible disassembly, and easier maintenance. Prefabricated interior renovation is an important part of industrialization and factory production in the construction industry. It has the ability to improve living quality, enhance the happiness and sense of achievement of users, and promote the sustainable development of buildings. However, prefabricated interior renovation still needs to be further studied and improved, and its application should be popularized.

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Disclosure statement

The authors declare no conflict of interest.

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