Construction Design of Assembly Module Based on Recycling and Application Simulation in Architecture

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Abstract: This research is based on the concept of material resource recyclability, with the modular module unit as the carrier, the monomer size, structure, material selection of the module unit, its structural form and application feasibility in residential buildings, etc. In this aspect, the adaptive design methods under different construction forms, environmental characteristics and use requirements are discussed. Under the condition of introducing energy-saving technology, the green efficiency evaluation and simulation analysis were further carried out on its application method. It will have a customized module unit with high efficiency, flexible use and recyclability, and dock with multiple functional spaces to effectively cope with many problems in the construction and renewal of urban construction in China. In order to provide theoretical basis and reference basis for relevant design practice in the future.

1 INTRODUCTION

In recent years, China's national economy has changed from extensive to intensive growth. Therefore, various problems such as overpopulation, traffic congestion, housing difficulties, environmental degradation, and resource shortages in urban construction and renewal are urgently needed to be resolved.

In the context of the era of sustainable building design and informationization of building industrialization, this paper discusses the structural design method of assembled modular unit at the beginning of design, which is conducive to the recycling of materials. Deepening design, construction, material selection, and the configuration of multiple monomers. Taking the residential building type as the research carrier, the design analysis and application simulation are carried out to form a feasible design method suitable for different application types and construction conditions. Furthermore, the application prospects of the fabricated modular unit body in architectural design and its feasibility to solve practical problems are proposed and demonstrated. It is expected to provide theoretical basis and effective reference for future research and project practice in related fields.

2 BASIC DIMENSIONS, CONSTRUCTION AND MATERIAL SELECTION OF THE MODULE UNIT

At the beginning of the design, the size, construction method and material selection of the module unit body should be considered based on the feasibility of the recyclability of various material components (Gao, 2005) and the disassembly and reorganization of the module unit as a whole.

2.1 Unit Size

In order to make the module unit applicable to various types of buildings, the common dimensions of various buildings should be referred to to obtain the appropriate dimensions of the unit body. Compared to public buildings, the size of the home is more stringent. Therefore, we mainly refer to the residential building room parameters when determining the basic dimensions of the module unit body. At the same time, due to the structural characteristics, the assembled steel structure building modulus can also be considered. In summary, we use 600 mm as the modulus to

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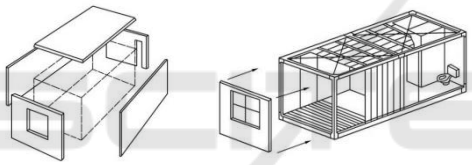
determine the frame size of the module unit body in the basic dimensions of 2.4 m, 3 m, 4.8 m three dimensions.

The spatial plane can be enlarged horizontally by a plurality of components or a combination of a plurality of cells. The 3.2 m rod piece can be used vertically, and the adjustable height can be adjusted to 2.5 to 3 meters. Walls, doors and windows are also 600 mm, and the plates are spliced and assembled to form suitable dimensions.

2.2 Structural Design

The structural system of the modular unit usually includes two types of skeletonless systems and skeleton systems (Figure 1). Among them, the skeleton-free system is suitable for low-rise, multi-storey, and 18-story high-rise buildings; the skeleton system can be divided into hollow frame, platform frame, cylinder structure and other different frame forms, usually with light panels for wall circumference. (Ma et al., 2018) The components are light in weight.



a. Skeletonless system b. Skeleton system

Figure 1: Schematic diagram of modular unit structure.

Taking the skeleton system as an example, the module unit body is composed of prefabricated standard members such as columns, beams, keels, and telescopic components, as shown in Figure 2 . The column is a hollow square column, and bolt holes are formed at both ends of the column, and are connected to the beam by bolts. The beam is a grooved section with multiple sets of bolt holes at both ends. (Wang, 2015) The connection of different positions is selected to meet the different depth and surface width of the single element (Figure 3). The height of the floor surface of the unit body can be adjusted through a plurality of sets of openings. The combination of the unit body and the site is more abundant, which is beneficial to lighting, ventilation, moisture proof and heat insulation.

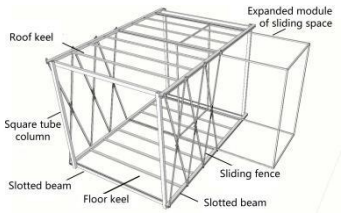


Figure 2: Schematic diagram of the modular unit body structure design.

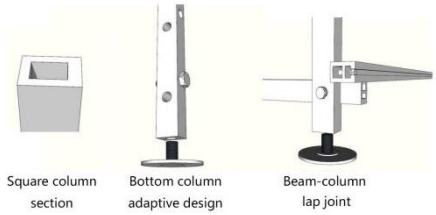


Figure 3: Module unit beam and column connection diagram.

When a plurality of monomers are combined, the monomers may be superposed as individual structural units, or may be connected by beams or column members.

2.3 Material Selection

In terms of materials, it can be flexibly selected according to the use and use environment. For example, the materials in the northern area are mainly made of heat-insulating and sturdy thick wall boards. In the south, the wall structure of fences is used, and the materials are permeable and moisture-proof. With the continuous development and application of new products, such as nano materials, intelligent environmental feedback materials, etc., the module unit body will be given more powerful functions and possibilities.

3 FABRIC CONFIGURATION BETWEEN MODULAR UNITS AND ITS DESIGN APPLICATION

As a basic construction unit, the module unit body can be built into a frame of a certain scale by means of interconnection and combination, forming a stable and firm structure, and is easy to install,

disassemble and reassemble. It can be used flexibly in many types of buildings.

3.1 Basic Unit Combination of Module Unit

In the combined application, since the module monomer can be self-contained structural system, the mechanical constraints in the combined connection are small. For the case where the number of superimposed layers is too high and the mechanical properties are complicated, an auxiliary support can be formed by adding a main structure.

According to the type of building, spatial scale, etc., the combination of unit bodies can include the following types: series, superimposed, overlapping, intersecting, parallel, misaligned, diagonal, upright, standing, etc. ,As shown in Figure 4. Further, the plurality of cells can be connected as a whole by paralleling and superimposing, and the corresponding device system can be configured.

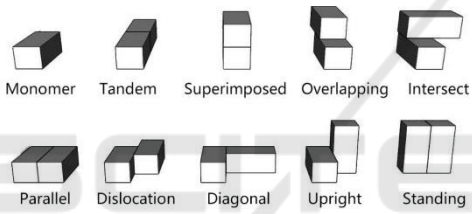


Figure 4: Schematic diagram of unit cell combination.

3.2 Application Type of Module Unit

In the form of application, it is possible to use single use, combined use, mixed structure, attachment operation, addition, space placement and the like (Figure 5). The independent application of the module unit is suitable for small-sized, single-function building types, such as single-family apartments, retail stores, etc.; through the composition of the monomer can get a larger use area and more space, such as: multi-storey hotels, Multi-storey buildings such as collective dormitories, office buildings, restaurants, exhibition halls, and warehouses.

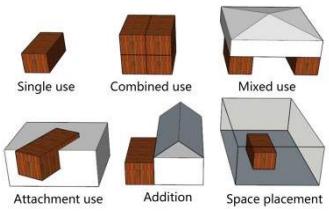


Figure 5: Application form of the module unit.

4 INFORMATIZATION AND INTELLIGENT PROMOTION UNDER THE CONCEPT OF RECYCLABILITY: TAKING RESIDENTIAL BUILDINGS AS AN EXAMPLE

Introducing the BIM information technology platform into the whole cycle of the construction industry has become a major trend in the industry. The introduction of BIM technology in the design stage of the fabricated modular unit can accurately record the data of each component and reduce the deviation between the design link and the construction link. Thereby saving construction costs and enhancing the recycling rate of components after module assembly, use and disassembly. At the same time, it can refer to the Internet thinking, establish the network leasing, sales and recycling mode of the assembled modular unit, and combine the networking and the use of big data to make the construction and application system of the modular unit body more powerful and precise. (Xu et al., 2018) Thereby improving the ability to update research and development, and improving the operational feasibility of recycling.

In the study, we take residential architecture as an example to explore several feasible application modes of modular unit in adapting to future urban development.

4.1 Design and Application of “Symbiotic Community” in Urban Center

First, we create a square pillar and beam based on 9*9 meters, set up the floor and traffic space on each 9-meter frame, and determine the area where the vertical traffic core is located, thus obtaining the basic framework of the building. . In the large frame, the overlapping and accumulating of the corresponding spaces are carried out according to the specific requirements and the modular construction principle, and an overlapping staggered growth organic building body with a certain withdrawal from each layer is formed, as shown in Figure 6 and Figure 7.

Figure 6: Architectural frame combination.

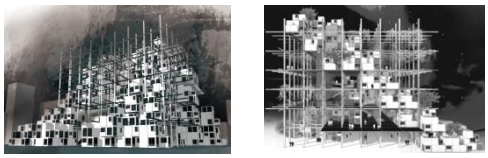


Figure 7: Space combination of modular unit buildings.

The spatial organization of the family can be configured independently according to the needs of the household population, forming a corresponding plane combination, as shown in Figure 8.

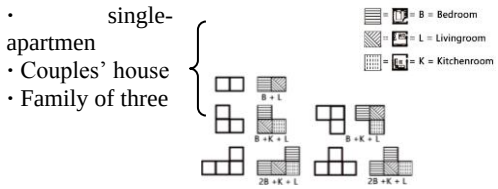


Figure 8: Plane combination diagram of unit module.

4.2 Design and Application in the Renovation of Traditional Residential Buildings

As the lifestyle of modern cities changes, to the same extent, traditional dwellings are no longer able to meet the needs of dwellings, and these buildings will gradually be replaced by high-rise buildings. We tried to keep each bedroom space, do modular unit processing, and combine the living space, kitchen and other functional spaces to get more open functional space, while the independent bedroom did not damage the privacy of the house. The shared space effectively promotes neighborhood communication, paying homage to the social environment of traditional architecture while preserving the convenience of modern architecture, as shown in Figure 9.

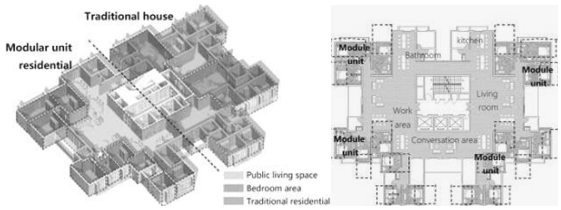


Figure 9: Space and plan views of the modular unit in traditional residential.

4.3 Insertion and Space Remodeling in Existing Buildings

For some buildings to be demolished or unfinished buildings, in addition to the fate of dismantling, is there any other way to extend its life? We still take the module body of 3*3 meters as the customized module unit, or promote it according to other required mode units, and introduce the original building space, as shown in Figure 10. They are like long-legged rooms, which are effectively combined, increased, decreased, and moved according to different needs in a free frame space, forming a new experience of old building renovation and resource utilization.

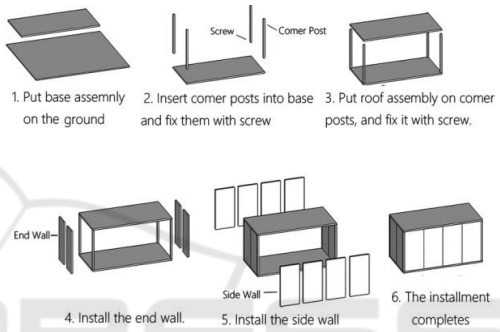


Figure 10: Constructed ways of the modular unit.

Those unfinished and modern buildings to be demolished only need to dismantle its basic maintenance structure, retain the original building's frame and core space such as traffic nuclear, pantry, bathroom and other necessary space, and then increase or decrease according to people's needs. A certain functional space, which meets people's production and living needs, promotes communication between neighbors, and gains a wider and more comfortable sharing space.as shown in Figure 11.

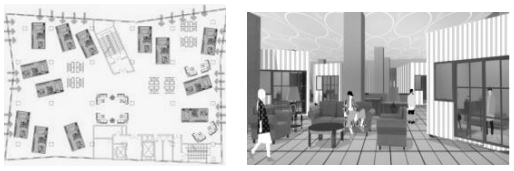


Figure 11: Reconstruction of the module unit in the abandoned building.

5 CONCLUSIONS

Gathering the advantagess of all types of modern industrial buildings, the generation and organization of customized modular units retains the original architectural construction model, which takes advantage of the construction of blocks and large-scale buildings, and promotes architectural design and material applications. A more industrialized point of view, thus proposed a more generalized building structure system and a new concept of urban construction.

The building is no longer a container that is fixed in three dimensions. It is a winged tourist who can move freely with the frame inside the site, go where it should go, and move with the owner's migration. Due to the adaptability of the modular unit, it is better able to adapt to the environment and needs, so that the building resources can be recycled. Therefore, the exploration and research of the architectural design of the modular unit body will not only be a new attempt in the future living space, but also a new discussion of the future office space.

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