J. COMBIN. MATH. COMBIN. COMPUT. 125 (2025) 375–391

Journal of Combinatorial Mathematics
and Combinatorial Computing
www.combinatorialpress.com/jcmcc

Combinatorial Press

Research on balancing strategies between modularization and personalization in prefabricated building design and simulation

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ABSTRACT

The research of modular and personalized balance strategy in assembly building design can improve the efficiency of construction and meet the demand of design diversification. Based on bim technology, an assembly building modular design method is proposed to determine the required space module, to determine the required space module, to strengthen the module structure, to set up the layout of the building, to formulate the modular panel and the assembly frame platform, and through the revit implementation of the three-dimensional visual design of modularity and personalization. The design of the 9 building of this article, in the collaborative function, spatial adaptability and the design diversity score in turn for 10th 10 "10" 9 points (full score 10). This article is designed to meet the demand of the building in daylighting and ventilation, the average daylighting coefficient is 6.440%, and the minimum value of the floor area of the building room is 18.25cent. Modular and personalized assembly frame structures have a better seismic resistance, and their limit cumulative energy consumption is 2.38 times the traditional way. Experts have the highest social benefit satisfaction in this article strategy, and the satisfaction score is 92.05.

Keywords: modularization, personalization, BIM technology, Revit 3d visualization, assembly building

1. Introduction

In the 1950s, China's construction industry was in the early stage of industrialization, and so far, with the continuous progress and development of science and technology, the assembly construction

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Received 27 February 2024; Revised 30 June 2024; Accepted 17 August 2024; Published Online 30 March 2025.

DOI: 10.61091/jcmcc125-26

technology has been gradually perfected and many breakthroughs have been achieved, such as digital modeling, which has been widely used in many fields [3, 5, 2]. In the current and future stages of China's urbanization, the goal of industrialized construction is no longer large-scale construction and rapid construction, but the use of standard-compliant materials and processes to achieve industrial transformation [1, 27, 10]. Humanized and variable design, exquisite processing and assembly, and focus on environmental protection will improve the service life of buildings [40].

At the heart of assembled buildings is modular design, where the building structure is divided into standardized modules that are manufactured in factories and assembled on site, the modular approach allows building components to be manufactured, transported and installed more easily [4, 18, 36]. By prefabricating and assembling in a factory environment, building components can be produced under stricter quality control supervision, which helps to minimize possible defects in construction and improve overall building quality [34, 38, 25].

Assembly building construction can be completed more quickly compared to traditional on-site construction. This is because the project cycle can be significantly reduced when modular components are manufactured simultaneously in a factory versus being built one by one on site [19, 28]. Assembled buildings typically utilize resources more efficiently, and manufacturing in a factory allows for better management of raw materials and less waste, in addition to relatively low on-site disruption and resource consumption during the construction process. Assembly building construction has potential advantages for sustainability and environmental protection, and can reduce the impact on the surrounding environment by reducing noise, air pollution and waste on the construction site [35, 26, 17]. Despite its high degree of standardization and modularity, assembled buildings can also accommodate a degree of customization, with the production process in a factory environment making it relatively easy to personalize designs to meet the needs of different projects [33, 6]. Assembly building construction is an approach that has the potential to revolutionize the construction industry by opening up new possibilities through increased efficiency, cost reduction and enhanced quality control [24, 8].

With the continuous development of urbanization and construction technology, assembly construction is gradually gaining widespread attention as an innovative construction method, and behind this trend, the issue of balancing modular design and customization needs is increasingly becoming an important topic in research and practice [16, 30, 32]. With its efficient and controllable features, assembly construction has attracted the attention of owners and construction practitioners, but at the same time, the growing demand for individualization and customization in different projects has brought new challenges to modular design [31, 12, 15].

Lacey et al. [14] described cutting-edge research on assembly modular building materials, noting that they rely more on connections between building modules than traditional building materials. Fard et al. [9] evaluates the safety risk factors of assembled modular site design and construction, and suggests stabilizing the structure during lifting, storage, and permanent installation, fall prevention for overhead transportation operations, and enhanced training for modular building assembly. Jiang et al. [13] revealed that assembly prefabricated building design is more conducive to sustainable socio-economic development than traditional building design. Munmulla et al. [23] verified that the removal of building corner columns and the removal of internal columns in modular building design significantly affects the stability of modular building design based on numerical test evaluation and experiments of three column removal schemes. Yuan et al. [39] attempted to introduce BIM information model into assembly modular design and optimize its parametric design, and explored the assembly prefabricated parts building process, in the development process as well as the information optimization process and related parametric design principles. Luo et al. [20] proposed to incorporate modular design theory research into assembly building design standards to improve building quality, reduce costs and achieve rapid group assembly, personalized and standardized design. The above studies on modular design of assembly buildings have focused more on the characteristics of building materials, construction safety, economic and environmental benefits, building robustness and parameter optimization, and less on customer personalization.

The literature on personalized housing building design mainly focuses on customer program interaction and cooperation, and mentions less on specific modular assembly building construction, such as the Hwang et al. [11] introduced the modular housing building design model of customer participation in customization and the modular housing platform (CEMHP), and argues that the modular housing platform (CEMHP) reduces the cost of communication in the process of personalized modular housing design, and promotes the development of the modular housing design process. Communication costs during the process and facilitates collaboration between clients and architects. Marchesi and Mat [22] talked about the practice of kilometer design theory in the process of mass customization design of housing buildings, and based on the analysis, it shows that kilometer design theory can scientifically and comprehensively understand the user's personalized housing demands and carry out relevant personalized design. Therefore, there is a need to further integrate and balance the modular design and personalized design theories and techniques in the design of assembled buildings in order to promote the personalized, modular and standardized development of assembled buildings.

This paper provides a brief introduction to assembly building, and analyzes the process flow as well as the characteristics of assembly building construction, and discusses the needs of assembly building design. Therefore, this paper proposes an assembly building design strategy that combines modularization and personalization, which fully exploits the potential of assembly building by balancing the advantages and shortcomings of both. The strategy is based on BIM technology and divides the household modules by referring to the elevation and core design, and then carries out multi-module combination. At the same time, steps such as determining the required space module and deepening the prefabricated structure of the module can realize the personalized design of the building.

2. Assembly building design process

2.1. *Demand analysis*

Assembled building [7] refers to the transfer of a large number of on-site operations under the traditional construction mode to factory processing, where building components and fittings are processed and fabricated in the factory and transported to the construction site, and then assembled and installed on-site through a reliable connection method.

The structural types of assembled buildings mainly include three types, namely, assembled concrete structure, assembled steel structure, and assembled wood structure. At present, assembled concrete structure is the most applied form of assembled structure. Therefore, the assembled building studied in this paper refers to the assembled concrete structure building.

Due to the development of assembly building, it makes the quality and economic efficiency of the construction project higher. Its structural components are processed in prefabricated factories and then transported to the construction site, where they are lifted and installed by large-scale machinery. The quality of the components is well controlled, thus ensuring the overall quality of the project, and at the same time greatly shortening the construction period and increasing the payback rate of the investment. The development of assembled buildings can produce both social and environmental benefits, turning construction workers into skilled workers and migrant workers into industrial workers, thus solving part of the social employment problem. At the same time, it also has the role of energy saving, reducing construction waste, reducing environmental pollution, and promoting the coordinated development of man and society. Therefore, with the development of science and technology and the continuous development of management, assembly construction has become an important guarantee for the modernization, transformation and upgrading of China's construction industry, as well as a need of the society and an inevitable trend of the development of the construction industry.

2.2. Assembly building construction

2.2.1. Process flow. The construction of assembled buildings can be divided into:

1) Design and production stage of components. The production of prefabricated parts in the factory is usually produced in an assembly line, and the production process mainly includes: pre-production preparation, mold making and assembly installation, steel reinforcement tying, decorative materials production and installation.

2) Loading and unloading of components and transportation stage. After prefabricated components are made in the factory, they need to be transported to the construction site according to the specified program, which is very different from the traditional cast-in-place construction. The transportation distance of components in prefabricated factories is generally within 150km, due to the large volume of prefabricated components need to put forward higher requirements for the transportation program and vehicle selection.

3) Lifting and installation stage of components. The lifting of the components is to lift the components according to the construction plan and place them in the designated location. In lifting, should be according to different types of components to choose the appropriate spreader. For prefabricated heat preservation exterior wall panels with a large span, it should take the balance beam lifting, and the angle between the cable and the balance beam should be controlled to ensure its stability.

2.2.2. Construction characteristics. With the increase of urbanization rate, the construction and construction method of assembly building will inevitably be optimized and adjusted with the improvement of its construction and management level. On the basis of field research, interviews and questionnaires, the characteristics of assembly building are comprehensively recognized and summarized.

(1) Prefabrication and factory production of components.
(2) Piling up a large number of components at the construction site.
(3) High demand for transportation cranes.
(4) Transportation distance, component size restrictions.
(5) Complex and difficult construction process.
(6) Efficient environmental protection and energy saving.
(7) Low workload of facade.

(8) There are deficiencies in the project acceptance specifications.

3. BIM-based modular design for assembled buildings

3.1. *Modular design approach*

Modular design [29] idea is in the traditional design concept combined with the modular idea gradually developed new ideas, due to the rapid development of information technology now, the idea in the subtle integration into the field of architecture. Modular design method based on this idea is mainly through the designer's analysis of customer needs and product functions, the building systematic decomposition and combination, decomposition is the decomposition of the functional areas of the house type, the combination is the combination of the modular unit, the different combination forms to meet the needs of different users of the building products, so as to complete the design of the whole building.

3.2. *BIM-based module design strategy*

3.2.1. Modular design process. Most of the residences in China use the core structure system, and this structure system has good performance in terms of structural performance, fire resistance, and usability of high-rise buildings, etc. In order to have a more long-term development, this section takes the core structure residence as an example to study the modularized building design process.

Figure 1 shows the modularized design process of assembly building. Using revit [37] to complete the core cylinder for design, the vertical facilities are made into a core cylinder, and users enter their respective modular units through the core cylinder. Around the core cylinder, a variety of permutations and combinations of living areas and public areas are made to determine the building form, which is able to roughly differentiate between the areas of each household type, and facilitate the structural, architectural, and electromechanical design of the household type in the area. The division of the internal module of the house type is based on the actual use, functional division according to the user's needs, combined with the physical environment such as light and other spatial layout and the design of the modular unit, the articulation of the modular unit, the layout of the public area, the internal decoration and other situations for comprehensive consideration. Categorized by spatial function, modular units are established, and different combinations of modules are studied according to users' requirements, and the diversity of house types is studied.

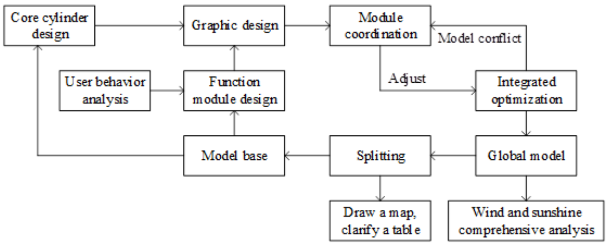

Fig. 1. Flow chart of modular design

3.2.2. Modularization of house types in the programme phase.

1) Reference elevation. In general assembly building design, the area module, house type design drawings in the schematic design, and the project model are usually in two project files. Through

Revit 3D visualization, top-down reference can be made during the design process, with the module unit design referring to the house model and the house model design referring to the regional module. The elevation setting in the schematic design stage is shown in Figure 2. First of all, Revit establishes architectural and structural elevations, and at the bottom of all elevations, it establishes two more program elevations, one for the house type design elevation, and the other for the regional module design elevation, which can be referenced in the subsequent design to make the design process more intuitive and efficient.

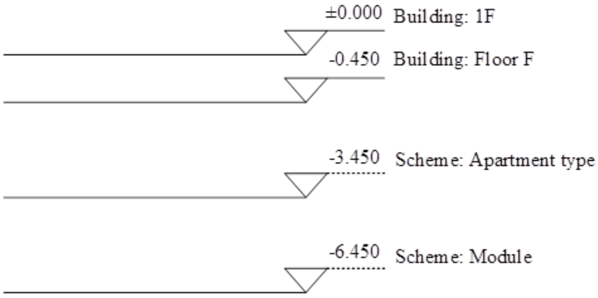

Fig. 2. Scheme elevation

2) Core design. Since the establishment of the core also requires the layout of the corresponding axis network, the initial design stage of the program does not determine the location of the axis network of the entire project. If the axis network is arranged here, it will be in conflict with the axis network of the later project model, so it is replaced by the reference plane in the program design stage. Establish the core cylinder wall, copy the wall, rename it as the program wall, set the elevation of the top of the wall as the elevation of the house model, and carry out room labeling and dimensioning after establishing the core cylinder wall. According to the fire code for high-rise buildings, the evacuation stairwell requires two independent channels, and comprehensive consideration is given to minimizing the common area and increasing the room rate and other needs.

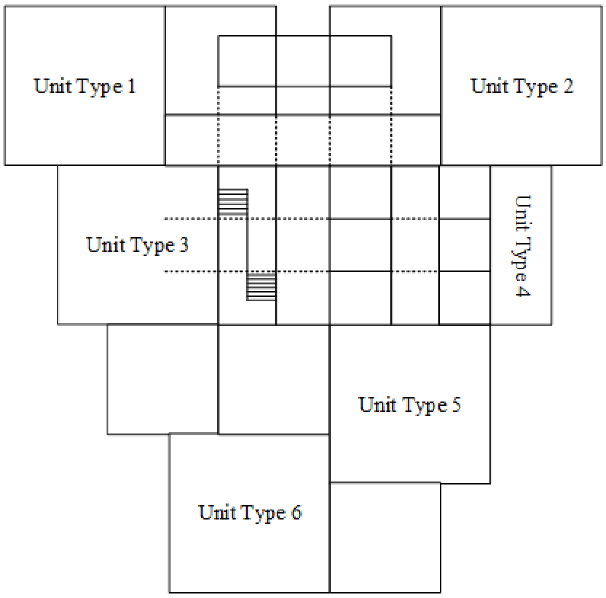

Fig. 3. Division of house type modules

3) Establishment and combination of household area modules. Through the Revit family stretch function to establish the regional module, adjust the parameterized control rules to facilitate the modification of the module area. After the module is established, the module family is copied and renamed as aisle module, basic module, splicing module and core cylinder module.

The project design needs to comprehensively consider the problems encountered in the use process, such as lighting is a problem that cannot be ignored in the building design, China is located in the northern hemisphere, the sunlight is mainly in the south, and the module splicing provides space for the windows of each house type to open to the south. Modular design house type structure is shown in Figure 3.

3.2.3. Modular floor plan combination design. This paper is based on the model library, through the model library to call the finished modules of previous projects, the material information of each module unit is also integrated in the model, which can control the cost well, diversify the combination of modules, and complete the design of the house type with personalization.

1) Module design. Before designing the functional modules, the whole house type is first divided into different functional modules, which can be decomposed into functional modules that are both independent and interconnected. And in the module design based on BIM technology [21], we should consider the factors that will be considered at a later stage in the traditional design, so that the structural design, architectural design, electromechanical design, and interior decoration design form a relationship that promotes and influences each other. Dwellings are divided into five main modules, living module, bathroom module, bedroom module, walkway module and storage room module. Module design will confirm the module dimensions by coordinating the modules, using a 30cm floor family within the house model as the module component for this design, and setting up the components through the Revit array function.

2) Module combination. With the assistance of BIM technology, architects can flexibly layout modules with standardized design, form different house types with multiple modules through different combinations, and provide a variety of design solutions to meet the diversified needs of users. In the module combination design, to follow the “less specifications, more combinations” principle, the kitchen, bedroom, walkway and other basic modules into a variety of house types. The entire modular design process follows a step-by-step nesting process from small parts and components to spatial modular units, then from the kitchen, bathroom, bedroom and other modular units to form a unique house type, and finally from the different house types spliced together to form a complete residence.

4. Individualized options for modular design

4.1. Personalized design content and method

Through the above scenario, it is evident that a modular approach to construction is an important tool for personalizing the design of assembled residential buildings. In order to achieve the goal of mass customization of prefabricated modular homes, the architectural design model must incorporate the results of two important components: data collection of customer requirements and prefabricated system design combinations. Current housing is still dominated by multi-storey and small high-rise buildings, so the main focus here is on user personalized design of small high-rise assembled houses.

There are five different levels at which the design can be unfolded, from general spatial requirements to detailed preferences:

1) Determination of the required spatial modules.
2) Deepening the prefabricated structure of the module.
3) Defining the detailed layout of individual spaces and the development of floor plans and elevations.
4) Customize material and color selection for exterior and interior components.
5) Assembling the overall assembly mix for the frame platform.

Individualized design can be achieved through these five steps.

4.2. Individualization options for modular design

4.2.1. Determination of required space modules. There are three tasks in the first level of the design step: family profile, lifestyle, and family activities. The first question tries to define the family profile of the new home. Here the household profile shows the main occupants of the new house, independent of the family profile. Once the system has collected enough information from the user's home profile, it generates a basic list of required spaces as a reference. For lifestyles, a list of additional required spaces needs to be created. At the end of this programming phase, the system provides a list for selecting any activities or features that need to be included in the new home. This is the final question in the Level 1 questionnaire, in the form of a checklist to avoid missing spaces that were not covered in the previous questions. All activities or functions within the house can be translated into physical space. For example, the client needs a series of activity spaces such as bedroom, kitchen, living room, bathroom and so on.

In this way, each spatial module offers a variety of combinations without interfering with other spaces. In addition, due to the modular structure, the space modules can be freely combined in a variety of space configurations, which can be selected according to the needs of different clients, the characteristics of the site and the available budget. Since individual requirements can easily be adapted to function and performance during the design phase and the life of the building, the building should be allowed to change to meet changing circumstances. This will also minimize building costs by focusing customization efforts on modules that are decisive for the client and on mass-produced modules that are not critical for the client, such as accessory space modules.

4.2.2. Deepening the modular structure. Structural support should be given to each unit module to provide protection, safety, comfort and resource availability and should include supporting loads and stability, standing interior and exterior, dividing interior spaces, connecting interior spaces, and providing and managing resources. Functionally independent structural layers allow the desired performance to be achieved without compromising with other functions, despite uncertainties. Each individual requirement is combined with other prefabricated components without compromising functionality or introducing unnecessary links. Such a design is therefore flexible and different customer preferences and climatic conditions can be easily accommodated. During the service life of the building, the construction layers can be easily disassembled, replaced according to their service life and then reassembled without damaging the whole. In addition, disassembled components can be removed or reused on a material basis in accordance with sustainable strategies. Construction is categorized into short-, medium- and long-term service life based on service life, and a distinction is made between permanent and replaceable layers based on factors such as climate and weather, load-carrying capacity, stability, and usage requirements.

4.2.3. Room layout and design. The geometry and plan boundaries of the building are determined before moving on to the room layout design phase. The task of this phase is to provide options for individual spaces. Options for different room layouts are regarded as interchangeable and compatible "space transformations". By splitting the modules again, functional basic sub-units are derived. For the customer, different habits correspond to different spatial layouts, e.g. different kitchen layouts reflect different cooking and lifestyles. The subunit modules can be organized into options to provide choices for customers' individual needs.

4.2.4. Prefabricated modular panels. Since the load-bearing and separating wall panels in this system do not interfere with other functions, the building shell can be designed as a module to increase the degree of prefabrication of standardized modular panels. In this way, the components are separated horizontally from the inside to the outside. Walls, windows, floors and roof prefabricated panels are assembled into spatial modules. The architecture is modular: the functional independence of the shell layers and their independent physical connections allow the client to personalize the shell from which the most preferred components are selected. In this way, the walls, windows, floors and roof panels can be mass-produced in order to minimize construction costs, while customization work is placed only on the parts that are essential to the client.

4.2.5. Assembly frame platforms. With a more selective conceptual basis to further increase user involvement. As an expression of the full life cycle of a building, assembled buildings are no longer the same as the old days when homes were built before they were purchased. The advantages of rapid construction and overall building control of assembly make it possible for users to buy before they build. Through the use of prefabricated components, the building space is assembled from disassembled components, making it easy for residents to flexibly assemble as needed.

4.3. Evaluation of the effectiveness of the application of modular and personalized balancing strategies

4.3.1. Evaluation of modularization of assembled buildings. Assembled buildings are often limited by their own structure, space form, often bring people the feeling of lack of flexibility, the building form is dull. In practice, designers often need to combine with other architectural structures to improve the original spatial relationship, or optimize the shape of the modular unit or through the combination of modules to achieve changes in the hierarchy of architectural space. Based on the above evaluation indexes, the three indexes of design and construction synergy and function, spatial adaptability and design diversity, with a score of 10 out of 10, this paper consults and researches the score of each building from industry insiders in the form of questionnaires.

The overall evaluation statistics of the modular and personalized design strategy examples of assembly buildings in this paper are shown in Figure 4, in which the building synergy and functionality, spatial adaptability and design diversity scores of nine assembly buildings with different degrees of modular and personalized design are counted. From the figure, it can be seen that modularization and personalized design of assembled buildings can improve the building synergistic function, spatial adaptability, and design diversity to a certain extent. For example, building No. 5, with a modularization and personalization degree of 20%, has a score of 3 for all of the above indicators. While building No. 9 fully applies the strategy of this paper, the expert's scores of building synergistic function, spatial adaptability, and design diversity on this building are 10, 10, and 9 in that order, which are significantly better than other buildings.

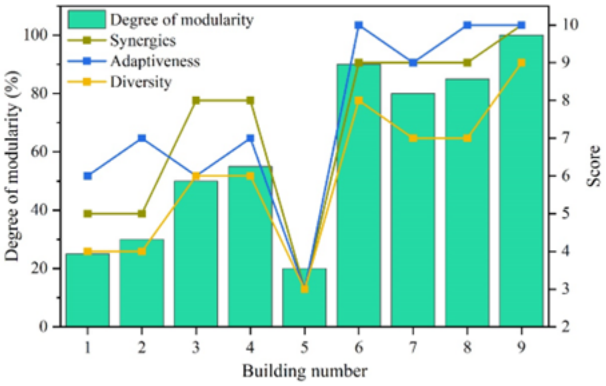

Fig. 4. The overall evaluation results of the design strategy examples

4.3.2. Simulation and analysis of energy saving effect. Using Swell to create a summer and winter daylighting study, it is possible to observe the effects of daylighting on the interior layout of the simulated project building.

Figure 5 shows the project daylighting simulation results. The analyzed results show that the building daylighting coefficient is 6.44% on average and the indoor daylighting coefficient is below 10%. According to China's green building evaluation standard, it can meet the requirements. The modularization and personalization strategy proposed in this paper enables users to effectively participate in the design of customized homes and verify the design scheme based on BIM technology. Users can select the customized components that meet their needs based on the combination scheme to realize the mass customized residence. Experiments have confirmed that this design mode can provide users with homes that are more compatible with their needs while meeting their requirements in terms of cost and energy consumption.

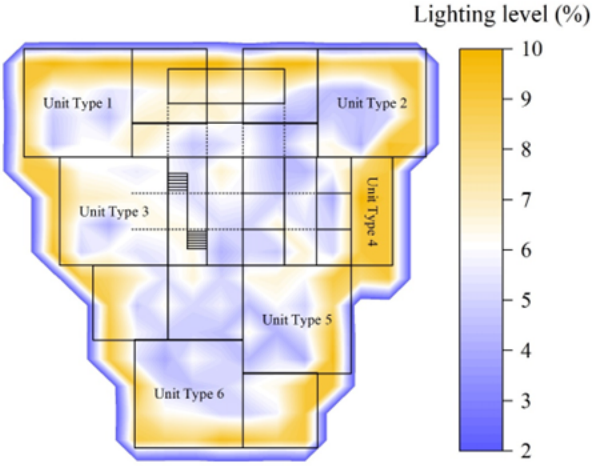

Fig. 5. Project lighting simulation results

The ventilation simulation condition is summer, the wind direction is 30° south east, the wind speed is 3.5 m/s. The horizontal profile of the ventilation simulation is set at 1.5 m from the ground, and the results of the project's ventilation simulation are shown in Figure 6. As can be seen from the figure, the building is well ventilated with obvious air convection. After calculation, the minimum value of the ratio of the ventilation opening area of the main functional rooms of the building to the floor area of the rooms is 18.25%, which meets the requirement that the ratio of the opening area to the floor area should reach 5% in cold regions.

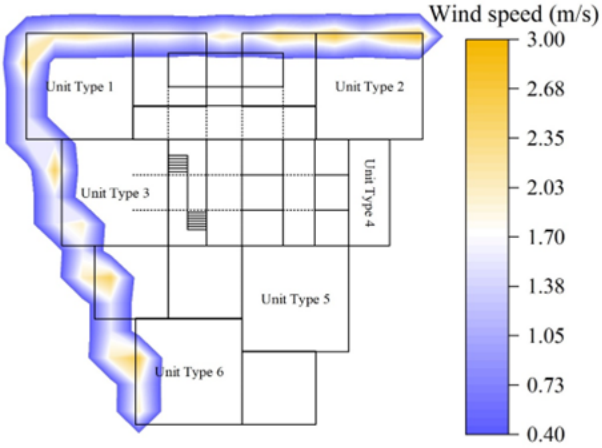

Fig. 6. Project ventilation simulation results

Reasonable natural lighting design can reduce the reliance on artificial lighting and reduce energy consumption, while providing a more comfortable and natural visual environment. Good natural ventilation design can effectively remove the dirty air and harmful gases in the room, keep the air fresh and circulating, reduce the reliance on machine ventilation system, and reduce energy consumption.

4.3.3. Safety assessment of assembly buildings. The strategy of this paper is applied to the construction of a new area of a local hospital to conduct seismic and durability experiments. The master plan area of the new district is about 367,743 square meters, with a planned construction of 2,000 beds and a total investment of 421,315,000 yuan. The planned projects include a combined Chinese and Western medicine children's hospital, a general practitioner training base and research building, an outpatient and emergency comprehensive building, a ward building, a pharmacy building, a teaching building, a medical and healthcare integration building, and a logistics service building.

1) Seismic performance. There is a significant difference between the modular design of assembled buildings and cast-in-place buildings in the discontinuity of the connection nodes, and the seismic performance of the node connections is a key indicator for evaluating the construction quality. In order to deeply verify the seismic capacity of beam-column nodes under the strategy of this paper, a beam-column node model is produced for load experiments and compared with the load experiments of nodes with traditional connection methods. The cumulative energy consumption is an important index to measure the energy dissipation ability of the node under vibration loading, which is of great significance for evaluating the seismic performance of the node. The results of cumulative energy consumption of beam-column assembled nodes of modular and personalized frame structure with traditional connection method nodes in this paper are shown in Figure 7. As can be seen from the figure, the cumulative energy consumption of beam-column nodes of the two connection methods has the same trend of change, and both of them show a significant growth trend. When loaded to the 20th cycle, both specimens enter the yielding stage, but there is a difference in the ultimate cumulative

energy consumption between the two. Specifically, the ultimate cumulative energy consumption of beam-column assembled nodes of the strategic building frame structure in this paper reaches 9.40×10^5 J, while that of the nodes of the traditional connection method is 3.95×10^5 J. From this, it can be concluded that the beam-column assembled nodes of the modularized assembled frame structure in this paper have excellent seismic performance, and their ultimate cumulative energy consumption is 2.38 times higher than that of the nodes of the traditional connection method.

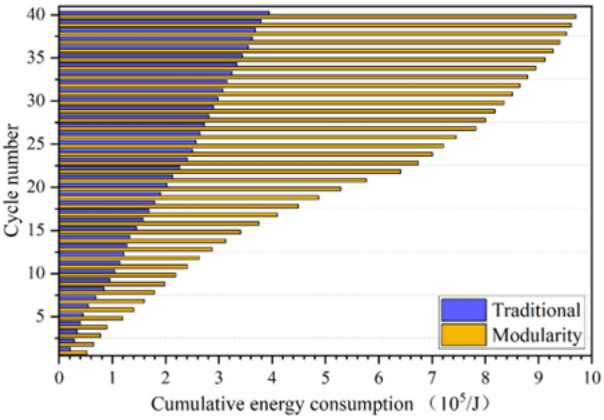

Fig. 7. The cumulative energy consumption of the node

2) Durability performance. In addition, the durability test was conducted on the building above applying the modular and personalized assembly building design strategy of this paper.

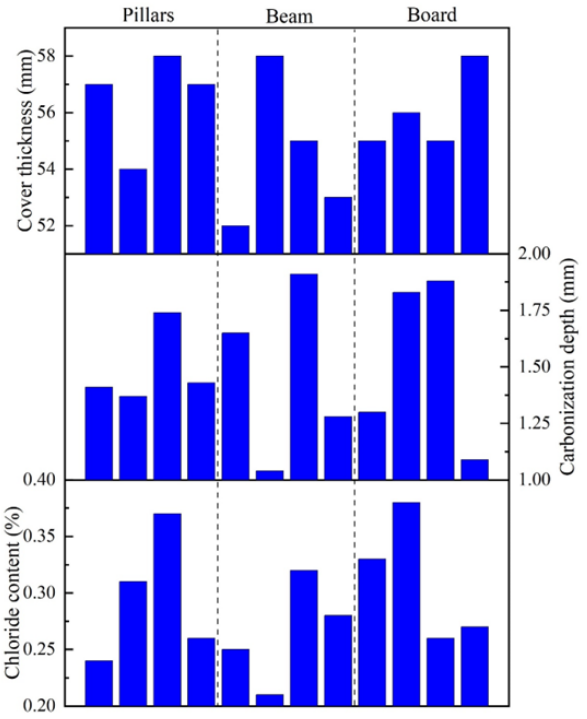

Fig. 8. Test results of concrete durability under this strategy

The building is fortified with an intensity of 7 degrees, and the structural safety level is 1. The building is an underground layer of reinforced concrete floor structure, local frame structure, lighting using steel mesh frame structure, the building has nine entrances and exits, the construction of which is mainly used as an underground human defense facilities, and later changed to an underground shopping mall due to the development of the times and business needs. The project is constructed by reinforced concrete, so its safety analysis is mainly for the current condition of reinforced concrete to detect and analyze, in order to ensure the safety of the use of the building, the durability of the reinforcing steel testing. The durability test of this project is carried out for different locations of beams, slabs and columns, and 4 places are taken for each component to be tested, and the durability test items include the chloride ion content of concrete, the depth of carbonation, and the thickness of the protective layer. The results of the concrete durability test under the strategy of this paper are shown in Figure 8. From the data depicted in the figure, it can be seen that in all three types of components, the chloride ion content is less than 0.4%, and most of them are concentrated below 0.3%. Meanwhile, comparing the test values of protective layer thickness and carbonation depth, it can be seen that the highest carbonation depth of the components at different locations is 1.91mm < 2mm, and the lowest protective layer thickness is 52mm, with an overall lower carbonation depth. In conclusion, it shows that the underground shopping mall constructed by the strategy of this paper has better durability and higher safety of each structure.

4.3.4. Sustainability and diversity satisfaction survey. In this section, a questionnaire was used to evaluate the feasibility of modular and personalized design sustainability and diversity of assembled buildings as the objective of the analysis. The questionnaire evaluates five aspects: environmental quality, energy consumption, social benefits, economic benefits and design diversity. The questionnaire invites 100 experts in related fields to evaluate multiple issues in various aspects, and assigns values to the expert evaluation results through the recovered questionnaires, so as to quantify the feasibility of this paper's strategy.

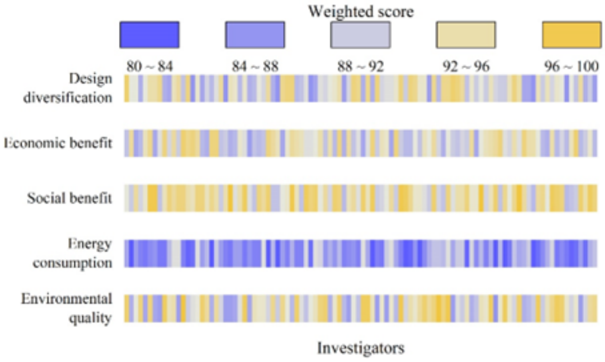

Fig. 9. The results of the research of the feasibility evaluation of the policy

Figure 9 shows the research results of the experts' satisfaction evaluation of this paper's strategy. From the figure, it can be seen that this paper's strategy in the environmental quality, energy consumption, social benefits, economic benefits and design diversification of the five aspects of the higher evaluation by experts. Assigning values to the evaluation results, the average scores of each aspect in descending order were obtained as follows: social benefit (92.05), environmental quality (90.71), economic benefit (90.02), design diversity (89.84), and energy consumption (84.64). Among them, social benefit and energy consumption received the highest and lowest ratings from experts, respectively. It shows that the construction of hospitals under the strategy of this paper can have a good and positive impact on the social level, which helps to provide equal healthcare services to social groups. However, the relatively low rating of energy consumption indicates that there may be a large waste of energy under this strategy, which does not fully utilize new energy sources such as solar energy and wind energy, resulting in a large dependence on traditional energy sources.

5. Conclusion

The study proposes and implements a balanced strategy for assembly building design that combines modularity and individualization based on assembly building needs. It aims to utilize the strategy to achieve a longer-term and diverse sustainable development of assembled buildings. The article verifies the effectiveness of this paper's strategy through a number of experiments, including satisfaction survey, modularization evaluation, energy-saving effect simulation, and safety assessment.

1) Modularization and personalized design can improve the synergistic function, spatial adaptability and design diversity of assembled buildings.

2) Under the strategy of this paper, the average value of building lighting coefficient reaches 6.44%, and the indoor lighting coefficient is between 4% and 7%, and there is obvious air convection in the building with good ventilation.

3) Modularization and personalized design enhance the cumulative energy consumption limit of the building nodes, after 40 cycles, the cumulative energy consumption of the assembled nodes under the strategy of this paper is 9.40×105 J. And the content of concrete chlorine ions is more than 0.3% or less, with a low degree of carbonation layer, which demonstrates the superior safety performance.

4) Experts' satisfaction with this paper's strategy is high, with satisfaction ratings of 84.64-92.05 for environmental quality, energy consumption, social benefit, economic benefit, and design diversity.

The strategy of this paper breaks down the building into several independent and functional modular units, which has good energy-saving effect and safety. Through personalized assembly, various modular units can be flexibly combined to achieve different functions in different usage scenarios or user demands. The design of assembled buildings maintains the efficiency and cost advantages of modularity while realizing the integration of design personalization and diversity. Although the strategy in this paper has a large application potential, there are still some shortcomings in the implementation of the strategy:

1) Quality control is not strict enough, and assembly building components may cause problems such as component deformation, breakage or loosening during transportation or installation.

2) Longer construction cycle, the modular unit on-site splicing and installation requires a certain amount of time, and the design and planning work may lead to prolonged construction cycle.

3) Limited design flexibility, assembly buildings usually adopt standardized or modular design, which has some limitations on the creativity of architects and designers, and it is difficult to realize personalized and customized design.

Therefore, this requires the relevant departments to improve quality control, optimize the construction cycle and enhance design flexibility. At the same time, more personalized and diversified building solution strategies should be provided according to the characteristics of market demand.

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