BIM Technology Integration in Modular Buildings

Bohao Dong
Department of Construction Engineering, Tongmyong University, Busan, Korea

Abstract: Modular building is a new building form, and the integration with BIM technology can effectively promote the development of modular building. This paper relies on the BIM technology software such as Tekla, Mida, Augin and Twin motion, uses the component generation method to model the modular building, simulates the model generation process, and outputs the bill of quantities and CAD drawings required by the project. The design process of modular buildings is proposed, and the rationality and effect of BIM technology applied to modular buildings are analyzed.

Keywords: BIM Technology; Modular Building; Components; Simulation

1. Introduction

1.1 Background and Purpose of the Study

1.1.1 Background of the study

The construction industry is one of the key sectors driving China's economic development. Over the past decades, China's urbanization process has accelerated, providing a huge market demand for the construction industry. According to statistics, the total output value of China's construction industry reached RMB 17.1 trillion in 2024, accounting for 6.1% of the country's GDP. At the same time, the construction industry employs more than 40 million people, providing a large number of opportunities for employment, and becoming an important channel for labor force employment. As China's economy turns to high-quality development, the construction industry no longer focuses only on quantitative growth, but more on quality and efficiency. This requires construction enterprises to strengthen technological innovation and management innovation to improve the quality and efficiency of construction projects. Secondly, the shortage of human resources is also a bottleneck in the development of China's construction industry. Although China's construction industry has a large number of employees, there is a general shortage of skilled workers in the industry. Finally, the development trend of China's construction industry is intelligent and sustainable development. With the advancement of science and technology and the application of information technology, the construction industry will move forward in the direction of intelligent development. Intelligent buildings, green buildings and energy-saving buildings will become the mainstream trend in the future.

1.1.2 Purpose of the study

Modular building is the promotion of traditional building construction methods, and is the inevitable trend of the development of the construction industry. Compared with traditional buildings, modular buildings can save labor, improve building quality, shorten construction period, keep construction costs under control, and improve the construction site environment. For example, the overall design in the design phase has solved the rework problem caused by insufficient coordination among traditional architectural disciplines; Prefabricated components are produced in the factory, and the dimensions of each component are determined in advance in the factory, which solves the problem of too many personnel on the construction site of traditional buildings, and also effectively controls the size deviation. Applying BIM technology to modular buildings can maximize the value of modular building design, prefabricated component production, construction process management, operation and maintenance management and other stages. Applying BIM technology to modular buildings can promote the development of modular buildings, so BIM technology is an important means of future development direction and development of modular buildings. This paper relies on the BIM technology software such as Tekla, Mida, Augin and Twin motion, uses the component generation method to model the modular building, simulates the model generation process, and outputs the bill of quantities and CAD drawings required by the project.

1.1.3 Problem formulation

By means of informatization, integrating BIM technology into the development of construction industrialization will help accelerate the transformation and upgrading of the construction industry to industrialization, which is also the trend of realizing the development of the construction industry. However, how to use BIM tools in modular buildings is the key problem to be solved at present.

For modular buildings, BIM technology can improve construction efficiency through real-time information sharing and advanced model building, promote the promotion of modular buildings better and faster, and help the construction industry move towards building industrialization.

1.2 The Scope and Methodology of the Study

This paper uses BIM technology software to study the combination of BIM technology and modular building based on the creation of BIM model. The research route is shown in Figure 1.

(1) Combing and analyzing the various aspects of modular building construction organization design.

(2) Adopting the method of theoretical research, we analyze the characteristics of modular building at the present stage and the future development direction by summarizing the related literature.

(3) This paper discusses the concept, characteristics and value of BIM technology, analyzes the problems in traditional construction management, such as the amount of information, the difficulty in keeping paper materials, and the low degree of visualization, and gives full play to the value of BIM technology in the construction stage.

(4) Summarize the current application status of BIM technology and related information technology, and provide theoretical support for the application of BIM based modular buildings in the design and construction stages.

(5) Use the designed module to simulate the building, produce various engineering drawings, and integrate BIM technology into the design stage to verify the applicability of BIM technology in the modular building design process. The construction process is simulated to realize the arization of the model.

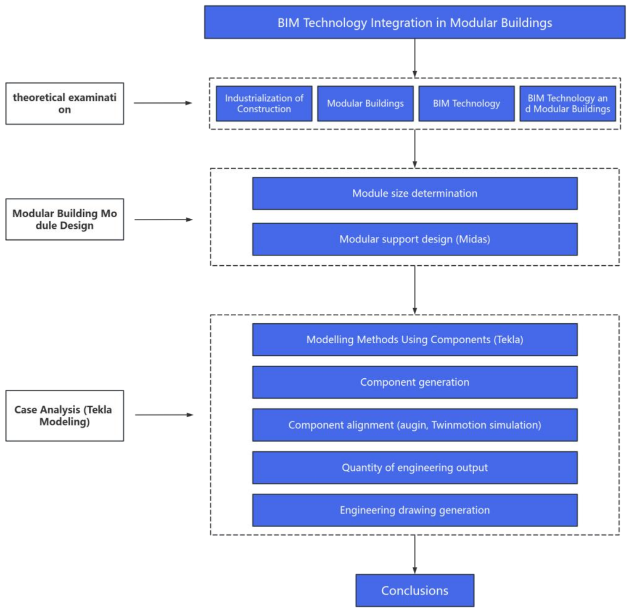


Figure 1. Research Route

1.3 Status of Research

1.3.1 Research status of BIM technology

(1) United Kingdom

The BIM technology in the United Kingdom was developed at the government's mandatory request. With the support of the British Construction Industry BIM Committee, the BIM technology was implemented in July 2011. In 2013, the British government issued the PSA 1192-2 standard. By 2016, the number of UK BIM technology users had increased from 39% in 2013 to 54%. In addition, the British government issued the BIM Level2 injunction, which was implemented on April 4, 2016 [1].

(2) Singapore

Singapore is one of the countries with the earliest and fastest development of BIM technology in Asia. Before the BIM concept was introduced to Singapore, the Singapore Building Authority (BCA) had realized the important role of BIM technology in the construction industry. In 2012, the Singapore government issued the Singapore Building Information Model (BIM) Guide. BIM technology has been widely used before 2015, and BCA has mandated that government projects must submit BIM information models. At the same time, local universities are encouraged to establish professional degrees in BIM technology, offer BIM technology related courses, and conduct BIM technology course training for students.

1.3.2 State of the art of modular building research

Singapore experienced three attempts at industrialization from the 1960s to the 1980s. In the third industrialization attempt, Singapore fully learned from the construction experience of France and Japan, and introduced their construction contractors and gave them some economic policy support. Singapore has formed an integrated system of prefabricated concrete components and mechanized formwork based on project construction experience and the actual national conditions. The state has given a lot of financial support. At present, the number of modular buildings in Singapore accounts for more than 4/5 of the total buildings, and prefabricated components account for 2/3 of the total components [2]. The Clement Canopy Apartment in Singapore is shown in Figure 2.

Europe is one of the main battlefields of the Second World War. The serious damage caused by the war has led to a large shortage of houses. In order to quickly solve the housing demand, we should vigorously adopt modular buildings with reference to the world's advanced building means, and formulate standard requirements to enter the industrial building system. Table 1 shows the differences of prefabricated buildings in some European countries.

Figure 2. The Clement Canopy Apartment in Singapore

1.3.3 Research status of BIM technology on modules and buildings

McKinsey analyzed the feasibility VE of modular building from economy, market, demand and other aspects, and concluded that modular building has development conditions in many markets around the world [3].

Bai et al. analyzed the application value of BIM technology in modular building design, construction, production and operation stages [4].

AFS has proved through experiments that compared with K-shaped support or other traditional supports, X-shaped support can provide more bearing capacity [5].

Song and Liu used Tekla to model, and conducted interference detection and quantity output on the model, and obtained that Tekla software has the advantages of simple modeling process and strong drawing ability [6].

2. Theoretical Examination

2.1 Industrialized Construction Methods for Buildings

The traditional building production mode is to separate the design and construction links. The design link only starts from the design point of view of the target building body and structure, and then transports the required building materials to the destination for open construction and completion disclosure and acceptance.

The industrialized building production mode is the production mode of integration of design and construction. After standardized design, the process of factory production and on-site assembly of components and parts. According to the comparison, it can be found that the design and construction are separated in the traditional way, and the construction specifications and technology in the actual construction process are not included in the design scheme. Building industrialization has subverted this traditional building production mode. Its biggest feature is that it embodies the concept of the whole life cycle and integrates the design and construction processes. The design process is not only the process from design drawings to construction drawings, but also needs to incorporate the standards of components and parts, supporting technologies in the construction phase, construction specifications, etc. into the design scheme, Therefore, the design scheme serves as the production standard of components and parts and the guidance document for construction assembly [7].

Table 2 shows the comparison between the traditional building mode and the industrial building mode.

Table 1. Differences of Prefabricated Buildings in Some European Countries

States	The main form of assembly, the	characteristics of industrialized systems
Germany	Structural system of laminated panels and concrete shear walls, with good durability	Government authorities work closely with industry associations and other organizations to improve the technical system and standard system, encourage different types of assembled building technologies, advanced machinery and equipment, materials and logistics, and get rid of fixed-size constraints
UK	Lightweight steel framing, reinforced concrete floor and wall panel precast systems	Adapting the structure of the region according to the development of different regions; developing a system for recognizing the professional level and skills, and cultivating the talents of the whole industry chain; and the high degree of cooperation within the industry, such as technical support from universities, research institutes, etc., as well as the close cooperation between the construction enterprises and the suppliers of machinery and equipment
France	Mostly using prestressed concrete assembled frame structural system or slab-and-column system	Mandatory modularization of the design, stipulation of component standards and combined application requirements, implementation of a "common building system", reduction of conflicts between structural and architectural design, and separation of component production and construction, with a focus on versatility
Sweden	A large number of companies have developed components for concrete, panel-wall assembly	It also requires modularization of design and the establishment of standards and regulations, and a standardized system based on the design of catalogs, which will gradually evolve to meet diversified needs and harmonize diversification and standardization
Denmark	Prefabricated components industry is well developed. Standardization of structural, door, window, kitchen and bathroom components	Influenced by France, where modularization of design is mandatory and the government encourages the use of structural components manufactured in accordance with National Institute of Standards (NIS) building standards for the construction of building products by means of financial support

2.2 BIM Technology Overview

BIM (Building Information Modeling) is based on the digitalization of various information of the construction project as the expression way to establish a three-dimensional model of the virtual building, integrate various information data through the model to simulate the real situation, form information sharing and transmission throughout the planning, design, production, construction, operation and other projects, so as to facilitate designers, component producers, constructors, etc. to use, update Revise to form the collaborative work of all participants [8].

The BIM concept mainly includes three aspects:

(1) BIM is a model of multi-dimensional information integration technology, which collects data of relevant project information and uses digital technology to express project entity conditions and functional requirements.
(2) BIM is a model for integrating data and resources at all stages of the project life cycle. Data can be calculated, searched and combined at any time, and all participants can use the data.
(3) BIM is a platform for sharing resources, which can solve the problems of decentralization and the unity of different types of data, enable the dynamic creation, management and sharing of project information, and provide a basis for the work of decision makers.

2.3 Outline of the Modular Building

2.3.1 Modular buildings
Modular building module unit as the basic prefabricated parts, unit according to different architectural functions in the factory manufacturing molding, and can be installed in the factory module unit inside the building equipment, different degrees of decoration, and then transported to the site, through the reliable connection to form the building as a whole. The proportion of prefabricated modular building can be more than 90%, and the modular unit can have a rich form, according to the use of functionality and architectural design flexibility to choose a combination of different units.

Table 2. Comparison between Traditional Building Mode and Industrial Building Mode

Comparison of traditional and industrialized production methods in the construction industry		
Stage	traditional production methods	industrialized production
design phase	not focusing on integrated design	standardized and integrated design
	Separation of design and construction	information technology synergies
		close integration of design and construction
construction phase	on-site wet work, manual work	Design and construction integration and factory production of components
	Low overall quality and professionalism of workers	assembly of on-site construction and professionalization of the construction team
Renovation phase	predominantly rough housing	synchronization of the renovation with the architectural design
	The use of secondary finishes	The finishes are consistent with the main structure
acceptance stage	Completion of step-by-step, itemized sampling	Quality inspection of the entire process
management phase	(b) Contracting out and low specialization	General Engineering Contracting Management Model
	Relying on subcontracting in the migrant labor market	The whole process of information management
	Pursuing the respective benefits of design and construction	Maximizing the overall benefits of the project

2.3.2 Characteristics of modular buildings
Modular building is the product of construction industrialization, is the use of standardized design, factory production, assembly construction, integrated decoration and information management as the main features of the building industrialization production mode of construction of buildings.
(1) Environmentally friendly
Through mechanized production and installation at the construction site, wet work is reduced, which reduces the large amount of construction waste generated by on-site construction.
(2) Energy saving
Prefabricated walls have an insulating layer, which can function as a warming layer in winter and a cooling layer in summer, thus reducing energy consumption.
(3) Shorten the construction period
Changing the traditional on-site pouring method, reducing a large number of procedures, reducing the intensity of work at the construction site, which also shortens the overall construction period.
(4) Reduction of labor costs
The use of on-site modular construction technology, high degree of mechanization, can

greatly reduce the number of on-site workers, saving a lot of labor costs, while also improving construction efficiency. The

(5) Safety and security

Improvement of the working environment for construction workers to avoid injuries and deaths during construction.

2.3.3 Individual units of modular buildings

The modular units are prefabricated in factories and transported by means of transportation to the site for assembly. Each modular unit is an independent structural body, which is mainly composed of space units by means of steel frames.

This kind of modular unit has the advantages of industrialized production, fully assembled structure, integrated system, modular system, mechanized construction and so on, so the construction speed is very fast. Factory prefabricated processing can ensure the high quality of construction, modular units in the completion of its temporary mission, can be moved to other places for recycling.

Generally, modules are divided into two different forms according to the load path. Load supporting wall module and corner column supporting module are two common types, both of which are applied in practice [9]. These two types of modules are shown in Figure 3. In the load support wall module, the load is transmitted to the ground through the wall. In the corner column support module, the load is transmitted to the ground through the corner column and the middle column.

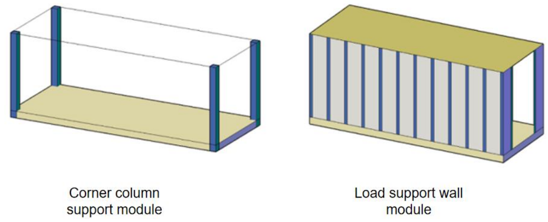


Figure 3. Two Module Forms

2.3.4 Modular building construction process

The module unit assembly process is shown in Figure 4: fabrication of lower beam and composite floor, installation of steel column, installation of upper steel beam, installation of bearing wall, installation of support, and installation of external wall [10].

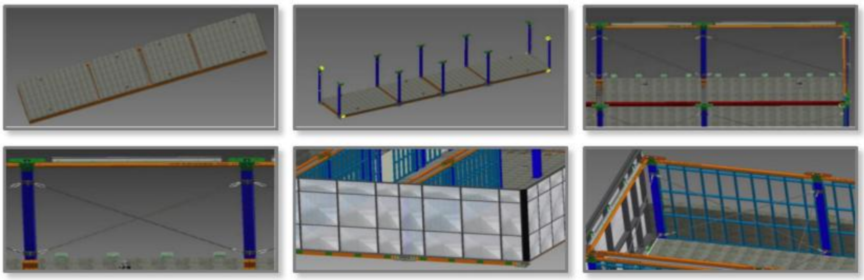


Figure 4. Modular Single Assembly Process

After the module unit is assembled, it is transported to the site through special transportation tools, and then lifted and connected according to the design drawing. Module hoisting and transportation are shown in Figure 5.

The construction process of modular buildings is shown in Figure 6: first, install the peripheral modules and the core modules with load-bearing walls layer by layer, and then install other modules. After the installation of the module on this floor is completed, concrete shall be poured at the connection of the prefabricated floor slab and the position of the load-bearing wall, and then the module on the previous floor shall be installed in the same way.

Figure 5. Module Hoisting and Transportation

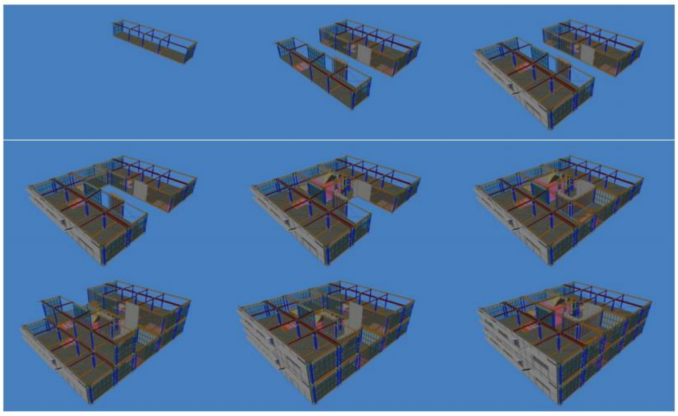


Figure 6. Modular Building Construction Process

2.4 BIM Technology and Modular Building

The traditional prefabricated modular building construction mode is from design to factory manufacturing to on-site installation process, but these three stages are separated, this separation of the workflow cannot be well coordinated, the whole system has a lot of irrationality, there are often design errors until the real construction and installation of the situation was not found, the direct impact of this is the contradictions in the design and construction of the resulting modifications, but also includes The direct impact of this is that the design and construction are at odds with each other, leading to modifications, as well as to longer construction periods and wasted resources, which ultimately affects the quality of the entire project [11]. In the end, the quality of the entire project is compromised [11].

BIM technology has realized the integration of scheme design requirements, manufacturing requirements and installation requirements. We can start to consider the requirements of design, manufacturing, installation and other aspects as a whole before the actual start of construction, maximize the avoidance of problems found after the start of manufacturing and construction, standardize the design process in advance, and try to eliminate possible problems in advance.

In brief, BIM technology plays a very good role in guiding modular buildings, the wide and comprehensive range of BIM technology connection can include the whole cycle from manufacturing to abolishment of design, construction, operation and maintenance, and demolition. Because of its digital attribute, various system elements can be digitally described, which can not only realize information-based collaborative design, visual assembly, and engineering quantity information sharing, but also perfect the whole process of building construction. In addition, BIM technology can be used for component simulation, collision inspection and 3D construction drawing in the stages of deepening design, component production, component lifting, etc.

3. Steel Modular Building Component Design

3.1 Determination of Module Size

In this paper, angle braced steel structure modular units are selected. Because their walls can be opened all around, they are more flexible in arrangement, facilitating the formation of a larger open space. Modules can be placed side by side on the top of another module to form various building configurations, so they are mostly used in office buildings, schools, and boarding houses. As shown in Figure 7, the size of the modular monomer is 6300 × 3000 × 3482mm, of which P 150 × 150 × 6 type steel is used for the surrounding columns, and C 150 × 75 × 6 type steel is used for the beams, all of which are made of SM355 material.

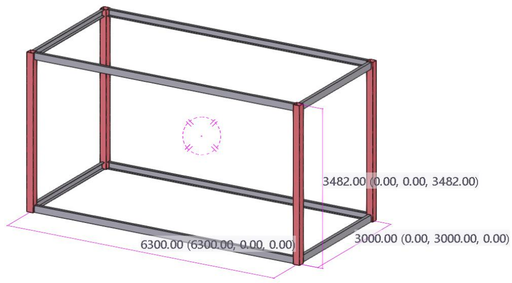


Figure 7. Modular Building Unit

3.2 Module Support Design

AFS (Australian Framing Solutions) has analyzed and tested the X-shaped support and K-shaped support, and the result is that the 150mm X-shaped support can provide a bearing capacity of 15kN, while the K-shaped support or other traditional support has a bearing capacity of 1kN. In order to verify its accuracy, we use Midas Gen software to verify it. 2.4m x 2.4m walls made of C90-37-1.2 concrete. 150mm strip support is selected, all of which are made of SM355, and 34KN horizontal load is applied. The experimental results are shown in Figure 8-Figure 10.

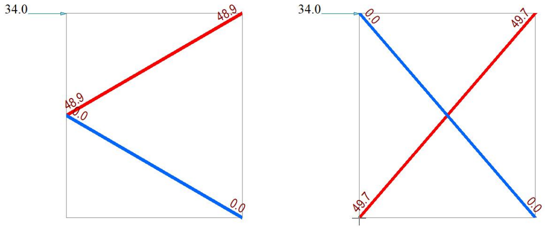


Figure 8. Support Internal Force Diagram

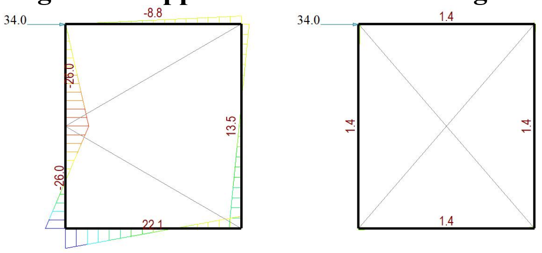


Figure 9. Internal Force Diagram of Column

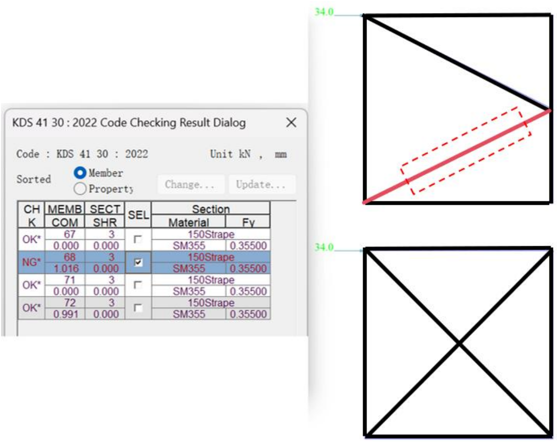


Figure 10. Stiffness Test Results

According to the analysis results of Midas Gen, under the horizontal load of 34KN, the K-shaped brace was damaged, while the X-shaped brace was intact, which preliminarily verified the superiority of the X-shaped brace.

According to the size, material and section type of the selected module in this paper, use Midas Gen software to model and analyze, and further verify the superiority of X-shaped support in the selected module by controlling the horizontal load as a single variable. The frame is 2100 × 3482mm in length, the column is made of P 150 × 150 × 6 steel, the beam is made of C 150 × 75 × 6 steel, and the band support is made of PL 120 × 6 steel, all of which are made of SM355.

In the first experiment, the horizontal load Hx=75KN was applied, the internal force diagram of the support and column was obtained, and the rigidity test was carried out. The results showed that the two support types were intact, but the K-type support had reached the limit state. The results are shown in Figure 11-Figure 13.

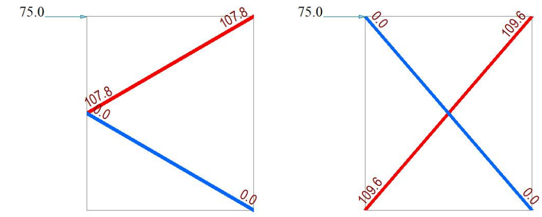


Figure 11. Support Internal Force Diagram

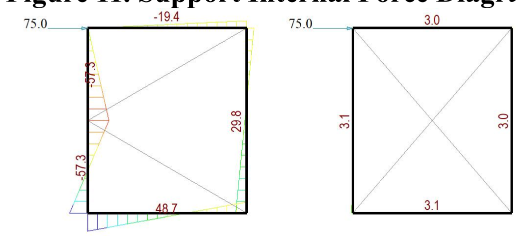


Figure 12. Internal Force Diagram of Column

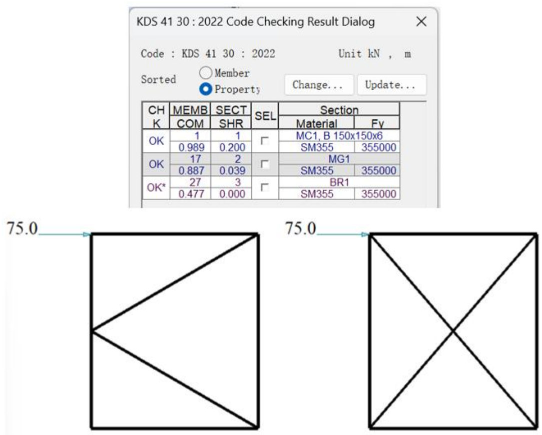


Figure 13. Stiffness Test Results

In the second experiment, the horizontal load Hx=158KN was applied, the internal force diagram of brace and column was obtained, and the rigidity test was carried out. The results showed that the K-shaped support column was damaged, and the X-shaped support was damaged. The results are shown in Figure 14-Figure 16.

Through the above three experiments, we can get the conclusion that the X-shaped support can share more force for the column and beam, and reduce the force borne by the main structure, which again proves the applicability of the X-shaped support in this module, so we choose PL 120 × 6 steel to make the X-shaped support as the support of this module. The effect of the generated support is shown in Figure 17.

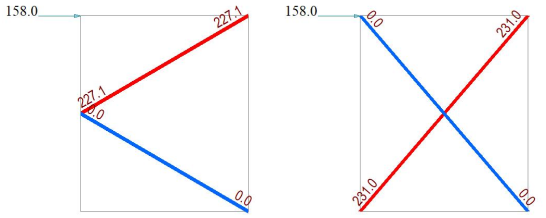


Figure 14. Support Internal Force Diagram

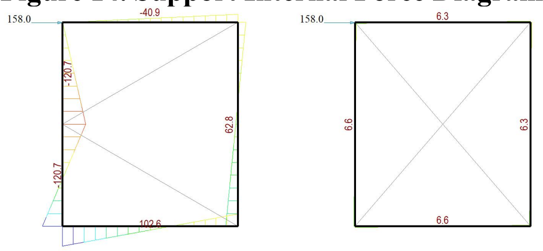


Figure 15. Internal Force Diagram of Column

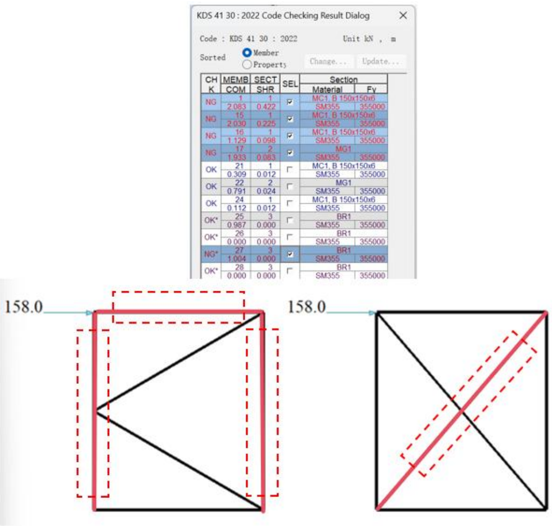


Figure 16. Stiffness Test Results

4. Modeling with Designed Modules

4.1 The Process of Modeling Using Component Generation Methods

The first step of modeling using BIM technology is to determine the size, number of floors and height parameters of the building, so as to produce accurate axes according to these parameters, which is also an important guarantee for the accuracy of the model. This paper is to model the modular building, which needs to determine the size of modules, the distance between modules, the arrangement of modules and the connection mode of modules. The number of feet and material of the module are shown in Figure 17. The spacing around the module is 15mm. However, since 150mm columns are used, when establishing the axis, the spacing around the module is 165mm, and the interlayer spacing is 30mm. The finally established axis is shown in Figure 18.

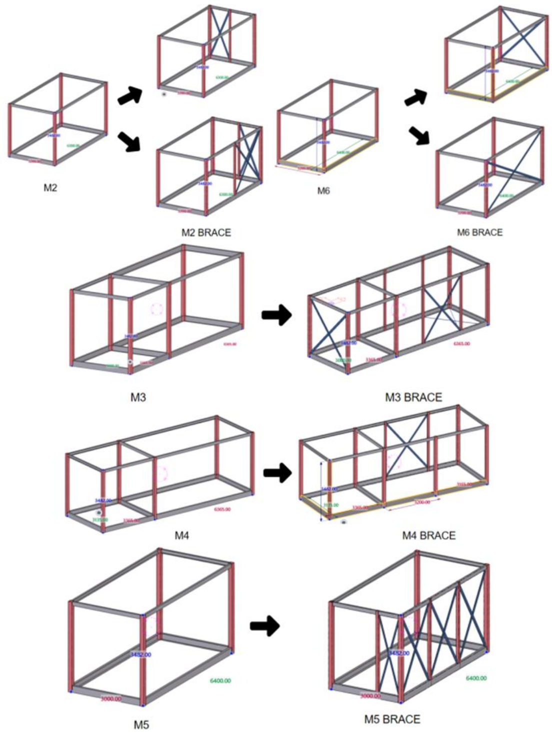
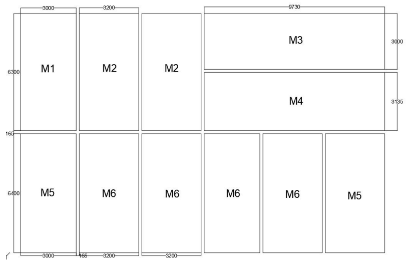


Figure 17. Module Support Generation

The second step is to create the components of the module, foundation and module junction. When building the components of the module, the method of building the module and the support together as a component is adopted, so that there is no need to separately build support for the module, which greatly improves the modeling efficiency. Considering the setting of the junction between the modules, the method of widening the C-shaped steel at the connection between the beam and the column is adopted, the length is 500mm. The completed module is shown in Figure 19 and Figure 20.

The foundation is set at the bottom of the column of the first layer module, which is composed of steel plates (PL9, PL20) to connect the ground with the module through the anchor rod. Four foundation forms are used for this modeling, as shown in Figure 21.



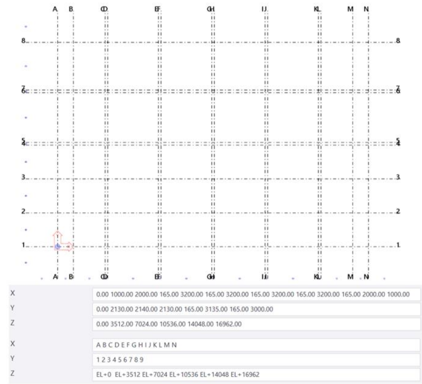


Figure 18. Module Arrangement Diagram, Axis and Specific Parameters

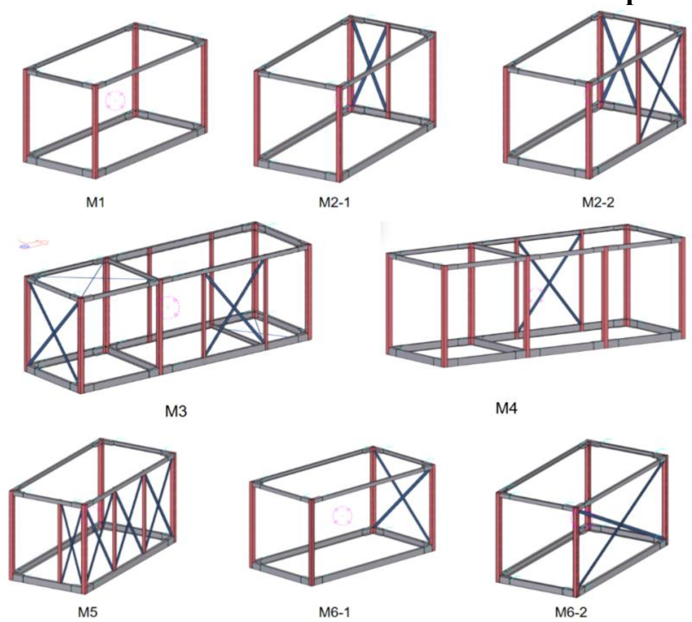


Figure 19. General Module Type

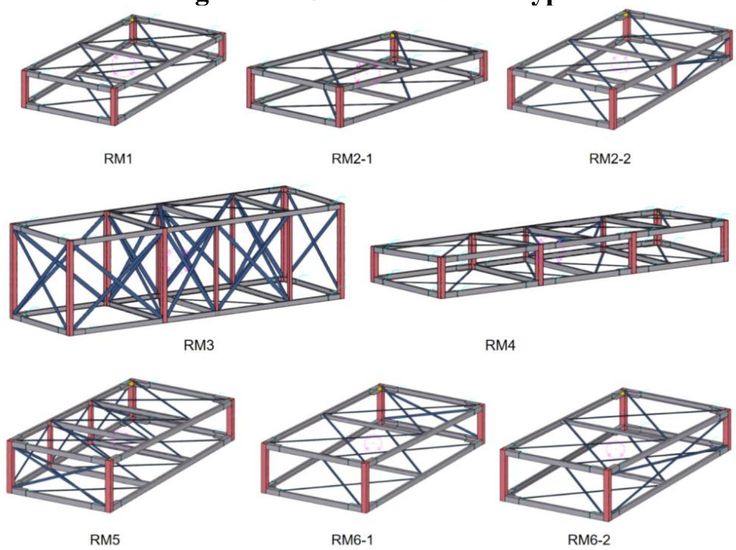


Figure 20. Top Module Type

The module connection part is composed of three steel plates (PL9 * 2, PL12), whose thickness is the same as the upper and lower spacing of the module, which is set in the upper and lower spacing of the module. The bottom beam of the upper module is connected with the upper beam of the lower module through the bolt group, and the left and right modules are connected through the anchor nails set in the left and right columns, so that the upper and lower modules can be connected with the surrounding modules. Eight joint forms are adopted for this modeling, as shown in Figure 22.

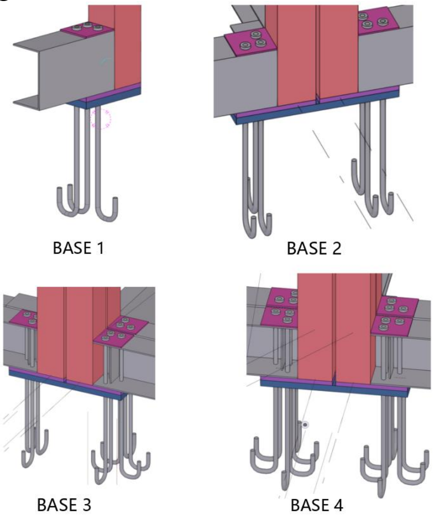


Figure 21. Basic Component Type

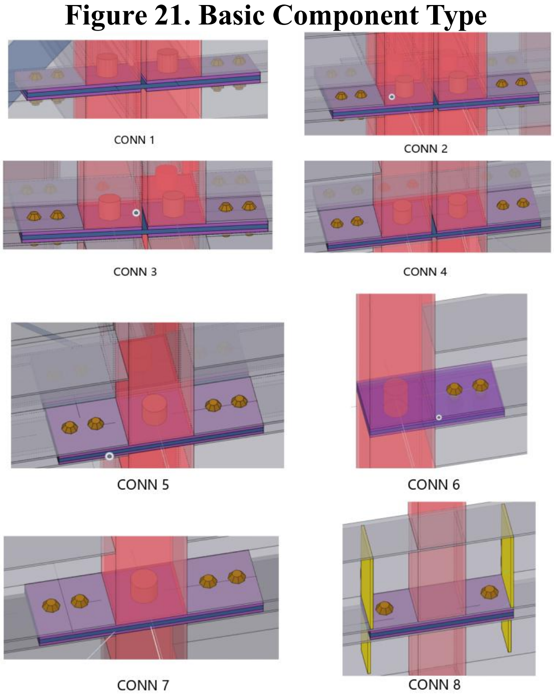


Figure 22. Connector Component Type

The third step is to place the modules in the designated locations and connect the modules to the ground and to each other by means of foundations and joints to complete the modeling of the building in the same way as the "building blocks" method. This modeling method does not work well for projects with low repetition of materials, but it maximizes the effect for projects where materials such as the same monolithic unit and joints are used repeatedly.

4.2 Component Generation

4.2.1 Module component generation

Take module M5 as an example, as shown in Figure 23, and build the M5 module at the specified location. As shown in Figure 24, click the icon shown in the figure in "Applications and Components" on the right side of Tekla software, select "Define Custom Component Functions", select the type as part material and name it "M5", click Next, select all components of the component, click Next, select one or two points for positioning in the component, and click Finish to complete the component generation of the module. As shown in Figure 25, when using a component, just click the icon of the component and select the location to be set in the model. Right click the generated component icon and select the "Component Edit" function to modify the generated component. This modification will take effect on all modules created by this component. In this way, if changes occur after modeling is completed, you only need to apply this function, and all modules will follow the changes. There is no need to change one module after another, making model modification easier.

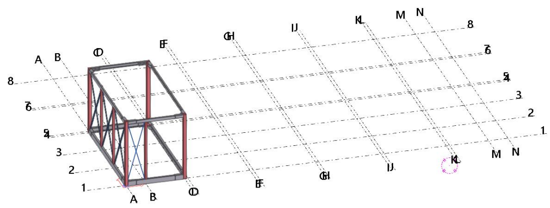


Figure 23. M5 Module

4.2.2 Generation of base and bond components

Use the same method to generate the components of the foundation and the junction. Take the joint CON6 as an example, as shown in Figure 26, set up a CONN6 joint at the specified location, select the function of "Define Custom Component Functions", select the type as the joint and name it "CONN6", click Next, select all components of the component, click Next, select the column as the main part, click Next, and then select the upper and lower beams as the auxiliary parts, Click Finish to complete the definition of the assembly part. When setting, just click the column and upper and lower beams to be installed in turn, and then click the middle mouse button to complete the installation. Similarly, the foundation and junction can also be edited and take effect on all this type of foundation or junction.

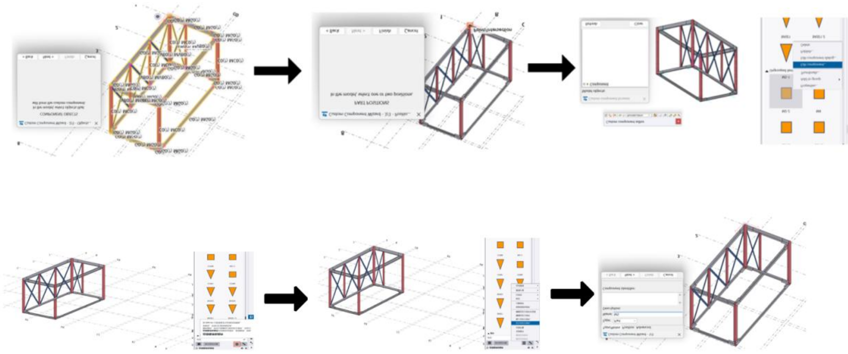


Figure 24. Module Component Definition Method

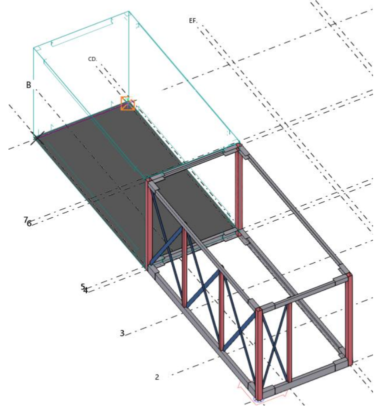


Figure 25. Component Usage

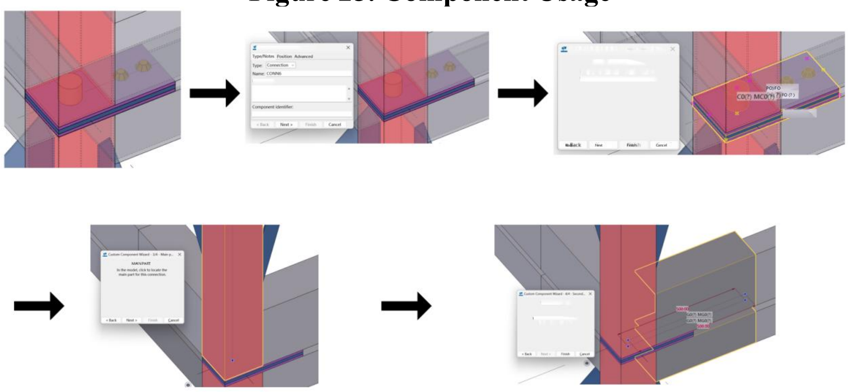


Figure 26. Definition Method of Joint Components

4.3 Component Alignment

The modules are arranged on the axis in turn according to the arrangement diagram, and the foundation and junction are set up to complete the modeling of the first floor, as shown in Figure 27.

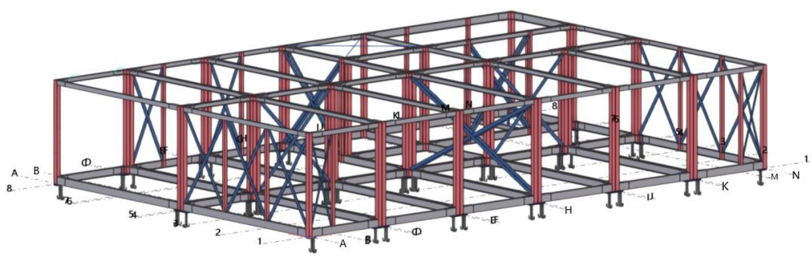


Figure 27. 1F Model

Use the same method as the first floor to model the second, third, fourth and top floors, and set the junction at the module connection to complete the modeling of the whole building. The finished effect is shown in Figure 28.

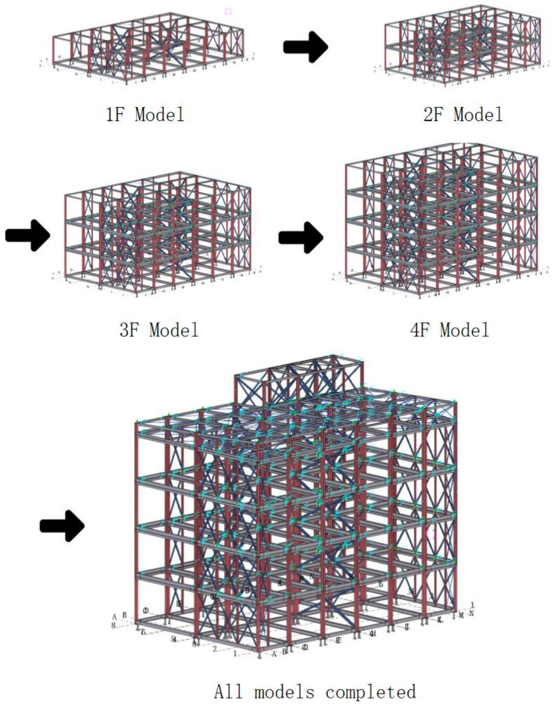


Figure 28. Modeling Process

4.4 AR Realisation

Augin software can realize AR visualization of the model, which can help us understand various information of the model more intuitively. As shown in Figure 29, using the export function of Tekla software, export the Tekla model in IFC format and import it into Augin software to realize AR visualization of the building model. Augin software can also generate two-dimensional codes for viewing building models on mobile devices anytime and anywhere.

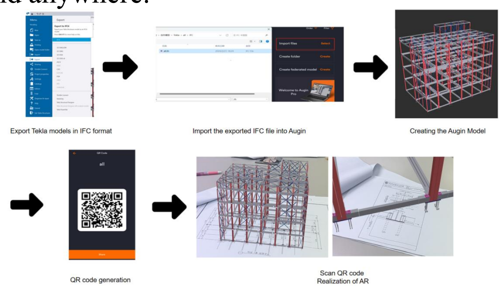


Figure 29. AR Visualization Process Using Augin

4.5 Construction Process Simulation

Using Twin motion software to simulate the construction process and generate two-dimensional code can more intuitively see the construction process of modular buildings. As shown in Figure 30, export the Tekla model in IFC format and open it in Revit software, export the model in FBX format [12] using Revit software, import it into Twin motion software, use Twin motion software to generate building construction process simulation video, and generate two-dimensional code.

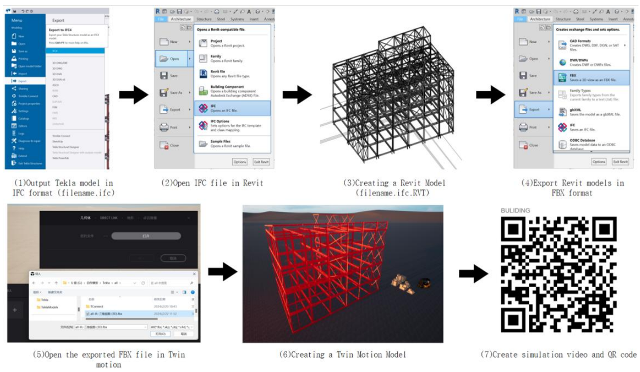


Figure 30. Simulation Method Using Twin Motion

4.6 Engineering Outputs

4.6.1 Reporting methodology

Before the mass production of the project, preliminary preparations such as collision check and setting number are required to ensure the accuracy of the quantity output. Step 1, as shown in Figure 31, select the "Collision Verification" function in the "Drawings and Reports" menu. This function can detect whether there is interference between components. If there is interference, you can use the "Part Cutting" function shown in Figure 32 to cut components to eliminate interference. After all interference is eliminated, the result of collision verification will be as shown in Figure 33, In this way, you can set the number in the next step.

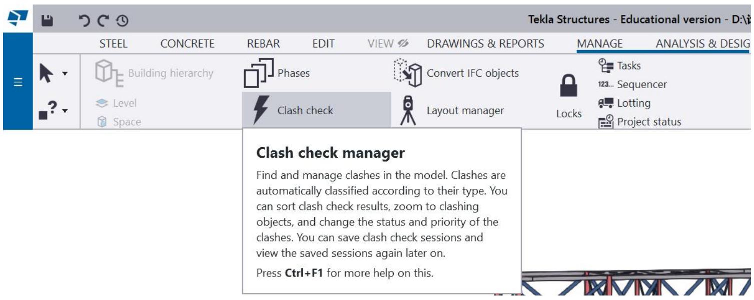


Figure 31. Collision Check Function

The second step is to set the number, as shown in Figure 34. Select the "Set Number" function in the "Drawings and Reports" menu to set the number of all components in the model. As shown in Figure 35, after setting the number, select the function of "Running number - numbering the modified object" to assign the number to all components in the model.

The last step is to output the quantities. As shown in Figure 36, select the "Create Report" function in the "Drawings and Reports" menu, select 150 - STEEL-LIST (PART-GROSS) as the report type, and select the module to generate the quantities to output the quantities of the selected module. Two types of reports, 150 - STEEL-LIST (PART-GROSS) and 150 - STEEL-LIST (PART-GROSS), can be used to output quantities of all parts and plates of the whole model. Taking M1 module as an example, the output results of quantities are shown in Figure 37.

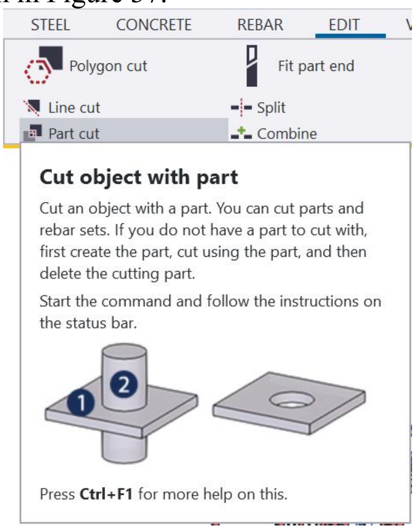


Figure 32. Part Cutting Function

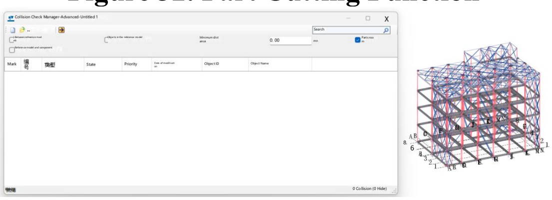


Figure 33. Collision Verification Completed

4.6.2 Organizer function

As shown in Figure 38, the "Manage Organizer" function in the menu can be used to manage all parts in the model by category. As shown in Figure 39, categories include but are not limited to component names, levels, part names, etc. This function can realize unified management or modification of components of the same class or layer, greatly improving the efficiency of modeling.

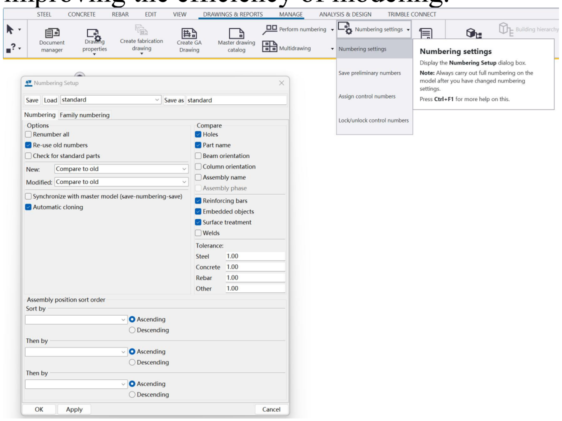


Figure 34. Setting Number

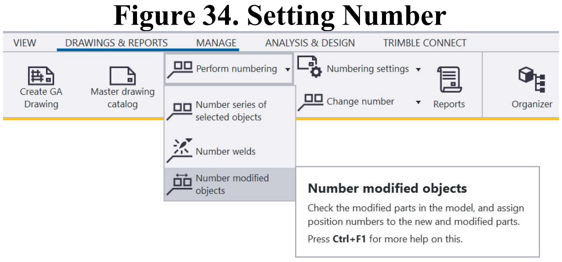


Figure 35. Operation No

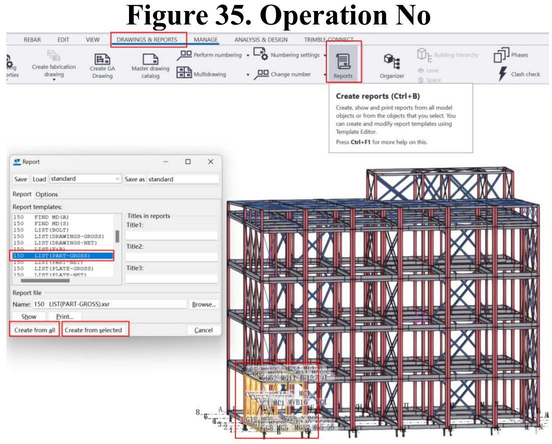


Figure 36. Quantity Output Method

M1 Engineering Quantity						
Profile	Number	Name	Height / mm	Length / mm	Width / mm	Weight / kg
	2	GIRDER	150	5,300	75	72
	2	GIRDER	150	2,000	75	27
C 150X75X6	4			14,600		198
	8	GIRDER	150	425	150	9
C 150X150X6	8			3,400		70
	2	GIRDER	250	2,000	100	41
	2	GIRDER	250	5,300	100	109
C 250X100X6	4			14,600		301
	8	GIRDER	250	425	150	11
C 250X150X6	8			3,400		86
	4	COLUMN	150	3,482	150	94
P 150X150X6	4			13,928		378
총계				49,929		1,033

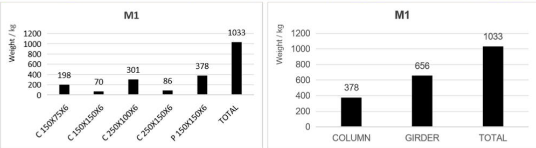


Figure 37. Quantities of M1 Module

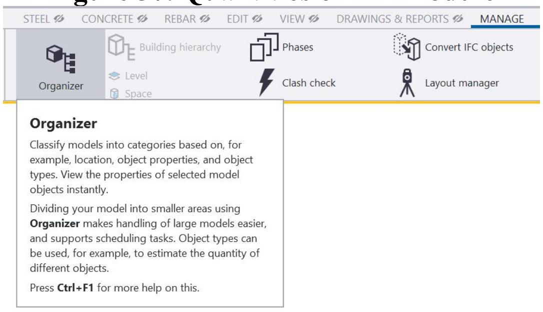


Figure 38. Organizer Function

After classifying components in the manager, you can select all components of the specified layer or name, as shown in Figure 40. This function greatly improves the efficiency of model modification.

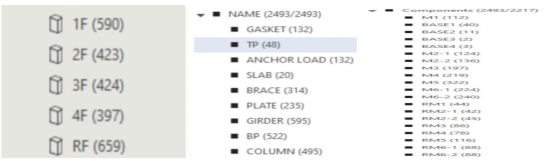


Figure 39. Organizer - divided by Layer, Name and Component

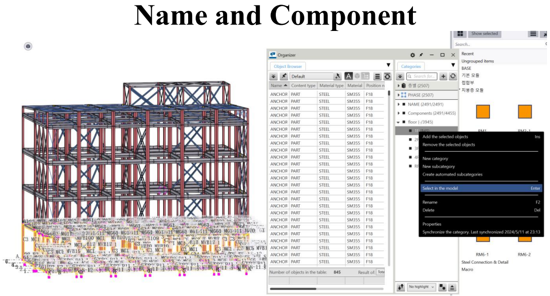


Figure 40. Use the Organizer to Select the Same Layer

4.7 Engineering Drawing Generation

Tekla software can be used to directly generate various CAD drawings required for construction, such as 3D drawings, elevation drawings, plan drawings and part drawings of the model, eliminating the process of repeated drawing production.

As shown in Figure 41, select Drawing and Report - Main Drawing Directory from the menu of Tekla software, right-click the drawing type to be used, and select Create Drawing. The type selected for 3D drawing in this paper is STL_3D (G), the type of elevation is STL_ELEV (FINISHI60), and the type of plan view is STL_PLAN (FINISHI60). Select the view to generate drawings in the pop-up dialog box, and click Create to generate the CAD drawings of the view. The generated drawings can be edited and adjusted in Tekla software. It should be noted here that because Tekla software generates drawings based on views, views should be checked before creating drawings.

The created drawings can be found in the "Drawings and Reports - Document Manager", which can uniformly manage the generated drawings and tables. The generated drawings can be exported to a CAD file in the format of filename. dwg by using the Document Manager. Figure 42 is the 3D CAD drawing of the model.

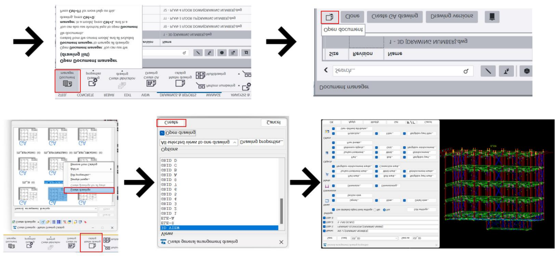


Figure 41. Drawing Generation Process

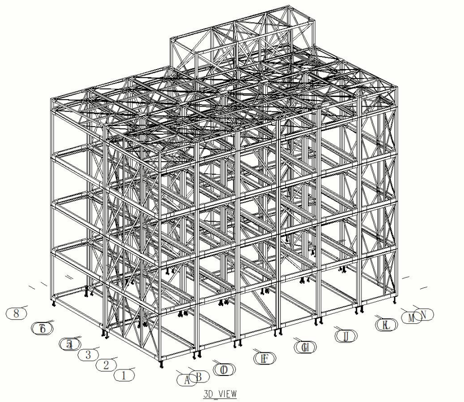


Figure 42. 3D Drawing of Model

5. Conclusion

This paper analyzes the current development trend of the construction industry, compares the construction methods of traditional and modular buildings, and concludes that the modular building meets the current construction requirements due to its advantages of fast construction speed, high engineering quality, less on-site work, good working environment, and low dependence on labor, etc. However, it develops slowly due to the low degree of standardization of components, the lack of standardized guidance, and the poor coordination of design.

The development of BIM technology has improved this situation. The development of the combination of BIM technology and modular buildings has realized technical cooperation, ensured the close combination of design and construction, and maximized the overall benefits of the project. Government support is also needed in the standardization and standardization guide of components. For this reason, this paper uses the component generation method to model the modular building, and carries out research on engineering quantity calculation, drawing generation, augmented reality and construction process simulation. The rapid modeling method of modular buildings is obtained through research, and the following conclusions are drawn:

(1) This paper compares and analyzes the support forms that can effectively exert the lateral support force of the module, verifies the excellence of the X-shaped support, and applies it to the modular building.

(2) Generate user-defined components with BIM characteristics from multiple modules, build and store them in the module database.

(3) The use of fabricated components dramatically shortens the process of standardized and repetitive work that is characteristic of modular construction.

(4) The editing function of the component can be used to easily modify the structural changes of the module, and the entire model can be automatically modified by modifying the editing of the component alone, which reduces the time and effort spent on design changes in a revolutionary way.

(5) Build a detailed BIM model (LOD 400) including the joint, which is not only visual, but also can effectively produce general drawings and detailed drawings.

(6) Through the BIM model, the quantities calculation table can be made according to the needs of users. It can easily meet the requirements of module category, section category, component category, layer category, etc.

(7) Apply BIM based modular building technology to the fourth industry, combine AR, real-time simulation visualization, etc., and provide the results as two-dimensional code.

(8) As mentioned above, the fourth industrialization can be achieved by combining the currently highlighted OSC (Off Site Constraint) based modular buildings with BIM technology. That is, intelligent construction can be realized.

References

[1] Du Kang. Research on BIM Technology in Virtual Construction of Assembly Buildings. Liaocheng University [2024-06-05]. DOI:CNKI:CDMD:2.1017.816423.

[2] Lim Seok-ho. (2012). [Special Planning] Current status of technology development in modular buildings and future tasks. Construction technology e Ssangyong, 2012. (Winter issue (v.65), 9-17.

[3] Nick Bertram, Steffen Fuchs, Jan Mischke, Robert Palter, Gernot Strube, and Jonathan Woetzel, McKinsey &Company (2021, June), Modular construction: From projects to products https://www.mckinsey.com/capabilities/operations/our-insights/modular-construction-from-projects-to-products.

[4] Bai S, Zhang Y K, Han F, et al. Analysis on the application value of BIM technology in prefabricated building. Construction Economy, 2015, 36(11): 106-109.

[5] Review of Strapping Vs. K bracing with AFS, 2023. https://www.scottsdalesteelframes.com/blog/news/kbracing.

[6] Song Linhu and Liu Changjiang. BIM modeling and design optimization based on Tekla. Proceedings of the Seventh National BIM Conference. Ed. Weifang College, 2021, 31-36. doi:10.26914/c.cnkihy.2021.044712.

[7] Ji Yingbo. A Study on the Development of Building Industrialization. Beijing: China Construction Industry Press.2011.04

[8] Zhao Xiaoxiong. Advantages of BIM technology in architectural engineering design. Bricks and tiles, 2022(5):100-102. DOI:10.3969/j.issn.1001-6945.2022.05.031.

[9] Gatheeshgar, P., Poologanathan, K., Gunalan, S., Shyha, I., Sherlock, P., Rajanayagam, H., & Nagaratnam, B.

Development of affordable steel-framed modular buildings for emergency situations (Covid-19). In Structures, 2021, 31: 862-875.

[10]Lawson, R. Mark, Ray G. Ogden, and Rory Bergin. "Application of modular construction in high-rise buildings." Journal of architectural engineering 2012, 18. (2): 148-154.

[11]Dai Wenying. A Study on Assembly Building Based on BIM Technology. Wuhan University, 2017.

[12]Nizam R S, Zhang C. Current state of information exchange between the two most popular BIM software: Revit and Tekla//Proceedings of the 1st International Conference on Sustainable Buildings and Structures. 2015: 29-31.

