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Research Article

Automatic System Design of Assembly Building Components for Sustainable Building Projects Based on BIM Technology

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The sustainable design that can consume minimal energy is the need of the hour. It has become a mainstream architectural design aim in recent years as a result of global environmental concerns. In light of global climate change, sustainable development is imperative to consider during architectural designs of the buildings and mega infrastructural projects. All the nations are developing assembly building tools widely to speed up the construction, but the material and design impact a lot, while we calculate the environmental factors such as carbon emissions. Assembly building component automation system is often used to complete components processing and to deliver the best project, which considers environmental concerns. The construction processing involves many factors such as carbon emission, energy consumption, waste management, and solar-based energy generation to make the overall project sustainable for energy. Therefore, this paper proposes a BIM-based (Building Information Modeling) assembly building component automation system targeted at adopting sustainability principles in the construction sector, which can consider various factors for maintaining eco-friendly environment. The BIM model of the assembled building components is designed and tested in a simulated environment. The system test result shows that the error rate of component design in this system is lower than that of the other two automation systems taken up for the comparative study and the proposed process is more stable, faster, and eco-friendly. Therefore, the design result of the assembly building component automation system based on BIM technology is scientific and effective for sustainable development.

1. Introduction

Due to the rapid development of the world economy, the rising cost of labor in the construction industry is increasing; the demand for construction speed is also increasing; the quality demand is also increasing and eventually in order to fulfil these demands; and the sustainable environment is compromised [1]. The advantages of the assembly building have gradually emerged [2]. Important decisions about the design of sustainable buildings are taken at their conceptual stages [3]. This technique ignores the early integration phases between the design and energy analysis processes, resulting in expensive backtracking to adjust the design to meet a set of performance requirements [4]. Quantifying environmental consequences and modeling the energy consumption of building components at the conceptual design stage are extremely useful for designers who need to make judgments about the design options for a more energy-efficient structure [5]. The assembly building has received greater attention and has made considerable development in the recent years [6]. Firstly, the application of information technology in the field of architecture is mainly limited to the level of automatic calculation and for preparing design instead of manual work [7]. Second, there is no standardized and uniform information standard in the field of architecture, which makes it impossible to realize information integration and sharing among different application systems [8]. In the design of the projects, construction operation, maintenance of engineering projects, utilization of natural resources, usage of eco-friendly materials, and sustainable energy play important role [9–11]. Therefore, the project developers attempt to use newer technologies, which are environment friendly and can certainly add the factor of sustainable energy for impacting the environment positively. Many researchers have presented different techniques in the recent years to develop the projects with the aid of computer-based techniques to check the simulated results before the actual development of the projects to analyze the impact of project development on the environment.

At present, many assembly building component automation systems have been developed and researched. In [12], the authors propose planning and control automated systems for prefabricated precast building components and explore the synergies between lean and BIM. The proposed model provides the assembly guidelines to construct cost controls for earthquake-resistant structures. Firstly, the hierarchical structure of cost control is constructed and many cost control schemes are obtained. Then, the method of cost/benefit is used to design the balance of benefit control constraints and to select the best method of building construction. In [13], the authors present an automated finite element analysis system for high-rise building groups under extreme earthquakes based on building information models. This paper analyzes the feasibility of introducing a building information model probes into the principle and advantages of building an information model. It puts forward the corresponding application mode of building cost management in different stages of building engineering. In [14], the authors study the different applications of assembly projects, which are based on BIM technology. In [15, 16], the authors study the application of BIM technology in prefabricated buildings and have concluded that BIM technology is a powerful supporting tool to develop prefabricated [17] buildings.

In [18], authors have proposed artificial intelligence-based nanorobots as building blocks, which are programmed to generate global shapes. However, the above methods have achieved some research results but did not consider the dynamic nature of the price. There is a strong subjectivity, resulting in low accuracy of evaluation. To solve the problem of the insufficiency of the building automation ability caused by the backward technical means and management mode, this research designs the assembly building component automation system based on the BIM technology. The building information model is the information integration technology of a multidimensional model, which is developed based on CAD (computer-aided design). The core of BIM is the information data of architecture, and the model is the carrier and integration of information. The information in the model can reflect the accurate information of architecture and promote the automation of assembly architecture. In [19], the authors have proposed CAD-based design to measure the strengths of the building and to analyze the sustainable features of the building, which can impact the environment. In [2], in order to ensure the effect of PLC equipment, the reset circuit of the hardware frame is designed. To ensure the smooth operation of BIM technology in assembly building automation systems and optimize the system communication interface, LoRaWAN gateway terminal is used as the main equipment. The software structure of the assembly building component automation system based on BIM technology is used as the foundation of software development, and the software part is designed. The graded load of the steel structure frame is also determined. Finally, the detection of component design results is completed and the features of the project are calculated. The proposed research work is using BIM technology and considering multiple factors to promote green environment.

The highlights are given below:

(1) This paper proposes a BIM-based (building information modeling) assembly building component automation system targeted at adopting sustainability principles in the construction sector, which can consider various factors for maintaining eco-friendly environment.
(2) Hardware design of assembly building components is discussed in the detail.
(3) Core controller settings are discussed.
(4) Rest line and communication interface design required for automation system are discussed in detail with the aid of proposed methodology.
(5) Software design of assembly building component is discussed and proposed in a detailed manner.
(6) Automatic assembly inspection of building components is discussed in detail.
(7) Simulation result gives clear comparison of evaluation error rate and speed of different system components and proves that the proposed system's performance is better than the existing systems.

The next section discusses about the hardware design of assembly building component automation system. Third section elaborate software design of assembly building component automation system. Fourth section elaborated simulation results. Fifth section concludes the paper work.

2. Hardware Design of Assembly Building Component Automation System

2.1. Core Controller Settings. S7-300 series PLC is selected as the core controller of the assembly building component automation system. It has the advantages of strong anti-interference, short cycle time, fast processing speed, easy to realize distributed configuration, high performance-price ratio, strong electromagnetic compatibility, etc. S7-300 series PLC adopts a modular structure design. Each modular unit can be freely combined and expanded, and its modular structure is shown in Figure 1, where the power module, CPU module, interface module, and signal module are displayed.

Power supply (PS): 24 V or 5 V direct current for each module of PLC;

CPU module: mainly used for user program execution, memory card can be used for memory expansion, while

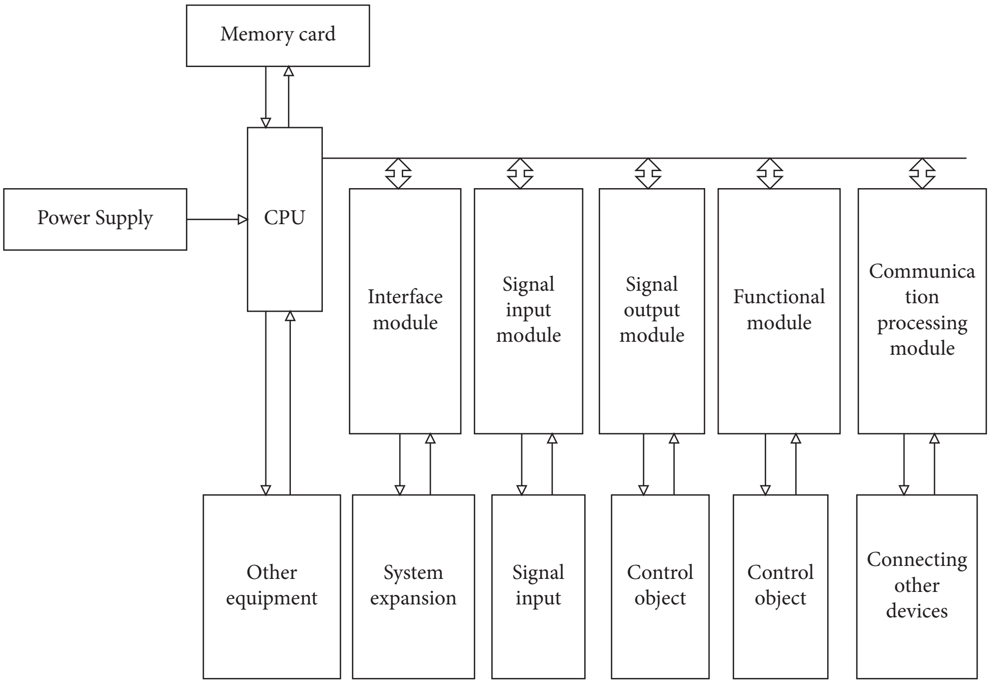

Figure 1: Core controller structure diagram.

some types of CPU integrated signal module and support PROFIBUS-DP communication interface [9];

Interface module (IM): realization of multirack expansion;

Signal module (SM): input and output of signal data, generally classified into an analog signal and digital signal [10];

Functional modules (FM): for positioning and high-speed counting in open-loop or closed-loop control systems;

Communication processing module (CP): used for the point-to-point network connection between the PLC and other equipment with a communication function. To ensure the controllability of the controller [11], its PLC hardware configuration is shown in Table 1.

The CPU of S7-300PLC adopts CPU 314C-2PN/DP module as the central processor of the assembly building automation system. It has a DP communication interface suitable for the system with a large program, many signal interfaces, and remote I/O. In addition, the CPU with 24 digital input/16 digital output and 5 analog input/2 analog output can be used for part of the input and output signal access while supporting the interface Ethernet PROFINET to achieve the connection with the host [12]. As can be seen from Table 1, the hardware configuration can meet the system's requirements and have some extensibility.

Table 1: Hardware configuration table of PLC for automation system of assembly building components.

PLC hardware name	Order number	Number (each)
PS 30 SA	6ES7 307-1EA01-OAAO	1
CPU 314C-2 PN/DP	6ES7 314-6EH04-OABO	2
ET 200M (IM 153-1)	6ES7 153-1AA03-OXBO	2
SM 331 (AI)	6ES7 331-1 KF02-OAB0	2
SM 331 (AI)	SES7 331-7KF02-OABO	8
SM 332 (A0)	6ES7 332-SHF00-OABO	2
SM 321 (DI)	6ES7 321-1 BH02-OAAO	1
SM 322 (D0)	6ES7 322-1BF01-OAAO	1
SM 322 (D0)	6ES7 322-1BH01-OAAO	1

2.2. Reset Line Design. The core controller of the design is introduced into the hardware frame of the original system. In order to ensure the effect of PLC equipment, the reset circuit of the hardware frame is designed. The reset line is an essential part of the core controller. The reset circuit enables each part of the core controller to be in a starting state of a datum and allows the core controller to start work from a determined initial state [13]. The extra time of the ATMega16 resets can be effectively controlled, and the capacitor assumes the role of power-on delay. And the controller has a built-in reset design, so the reset circuit outside the AVR can be designed as a 10-k resistance in series between the VCC and the bottom line. If you want to improve reliability, you can also series a capacitor to reduce interference.

In-circuit design, to lock the reset input voltage clamp at VCC 0.5 and add VD3 (1N4148) when the system is powered down, VD3 can short-circuit the resistor, let the CO discharge quickly, and reset the circuit in this way of fast discharge. When AVR is at work, the reset pin changes to a low level when pressing the SO switch, triggering an AVR chip reset. To sum up, this paper designs an ATMega16 minimum circuit, reset circuit, and crystal circuit and finishes the control of each system module's signal transmission and operation processing. The circuit of the main controller module is shown in Figure 2.

The reset circuit is used to control the main controller in the system and connect it with other devices in the hardware framework to determine the use effect of the main controller.

2.3. Communication Interface Design. To ensure the smooth operation of BIM technology in assembly building automation systems and optimize the system communication interface, LoRaWAN gateway terminal is used as the main equipment. LoRaWAN's gateway terminal's hardware design should focus on the LoRa transmission network's wireless part, the transmission part of the Ethernet network, and the power supply and low power consumption part. There are many kinds of MCU-connected external device chips, and different chips have different interface protocols, in addition to ADC, DART serial port, SPI, I2C, and so on. The following details on the SPI and I2C interface definition are prepared for the subsequent software design.

2.3.1. SPI. The serial peripheral interface (SPI) is a high-speed clock signal from Motorola that enables highly reliable data transmission. The SPI mainly consists of the following 4 pin signals:

(1) CS selects signals from the chip one by one, which are generally low-level and effective.
(2) SCLK one by one synchronous clock signal, generally output by the host computer.
(3) Master and slave signals of the MOSI (mainframe output and slave input).
(4) MISO master input and slave output signals (master input and slave output).

SPI can be based on communication needs, the appropriate multiplexing to reduce the signal pins, such as point-to-point communication can be selected from the chip signal directly connected to the low-level signal; or according to the agreement, the MISO two signal pins, in time-sharing multiplexing mode, enable half-duplex communication. Thus, the SPI can be configured to communicate as low as 2 lines.

2.3.2. I^2C. Interintegrated circuit (I2C), translated as integrated circuit bus, is the abbreviation for I2C bus, a serial synchronous communication bus developed by Philips in the 1980s to enable CPU-like controls to connect to low-speed peripherals. The I2C bus consists of the following two signal pins:

(1) SCL—serial clock signal, generally output by the host.
(2) SDA—serial data line, which is a two-way transmission signal with time division multiplexing.

The network line is used as the basis of design, and the network terminal of the original system is optimized. The gateway terminal is equipped with a USB interface because MCU uses a 3.3 V level, and standard USB uses an SV level. However, MCU can connect the SV signal directly, but an ADUM4160 USB isolation chip is added at the connection of two terminals to ensure stability.

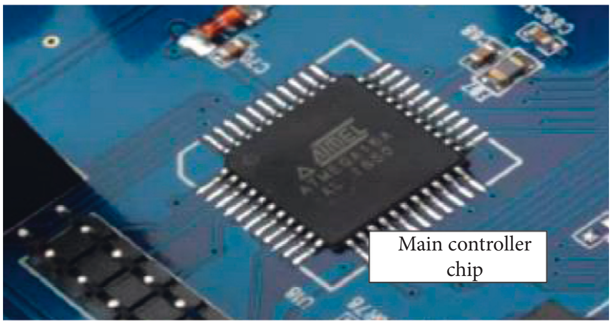

Figure 2: Physical diagram of main controller circuit.

The gateway terminal also needs to carry on the TCP/IP communication with the server; therefore, it also needs to consider the Ethernet access way on the gateway terminal. Microchip (Microchip)'s Ethernet access chip ENC424J600 will be used in this scenario. Compared with the standard ENC28J60 chip, the ENC424J600 will support SPI mode and the 8-bit parallel operation mode of the PSP. While the ENC28J60 will only support SPI mode; the ENC424J600 can support up to 100 Mbps rate, while the ENC28J60 will only support up to 1O Mbps; in the case of the same 3.3 V power supply, the ENC424J600 will have a maximum running current of 117 mA and the ENC28J60 will have a maximum running current of 180 mA.

The hardware design of the whole system is still based on the principle of low power consumption, which can meet the requirement of system function and reduce the power consumption as much as possible. In order to improve the reliability of the system, the hardware of the optimized system is used as the basis of software development.

3. Software Design of Assembly Building Component Automation System

To improve the effectiveness of system software development, we set the system software structure as shown in Figure 3.

The software structure of the assembly building component automation system based on BIM technology is used as the foundation of software development, and the software part is designed.

3.1. Input of Assembly Building Parameters. Firstly, we use Autodesk Revit 2017 software to model the structure arrange of the wall, column, beam, board, Revit model, and prefabricated component construction drawing to split and draw the prefabricated component and store it in the prefabricated component library. We complete the prefabricated component drawing and carry out architectural decoration and decoration design in Revit 2017 software. We added the standard floor according to the structural floor

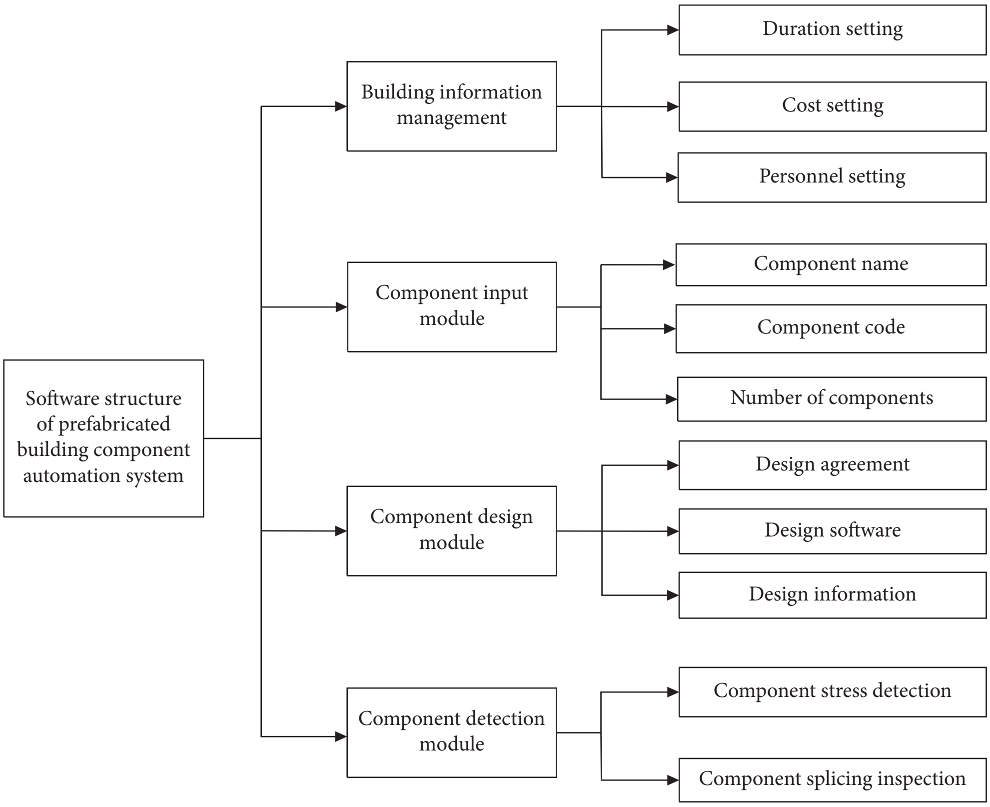

Figure 3: Software structure of assembly building component automation system.

elevation and assembled the floor. We connect to the structural model through the Revit interface and enter the assembly building parameter.

Table 2 shows that the code table of building components is input into the system, and this is regarded as the basic part of automation processing components through the use of related technologies and component automation.

3.2. Computer-Aided Processing of Building Components. We input the design parameters into the system, use BIM technology to combine the parameters with the code of the building components, form the design table, and complete the computer-aided processing of the building components. In view of the computer-aided processing of concrete prefabricated components, the ideal state is that the prefabricated components processing equipment directly extracts the information needed for processing the components from the BIM model of the assembled building components. Still, the data organization of the BIM model of the assembled building components provided by different BIM software is very different. At the same time, there is no uniform BIM standard widely accepted by various specialties and units [14]. Therefore, it is necessary to organize the BIM data in a specific format in CAM of prefabricated components, and the machine will identify the data and then arrange the production of prefabricated components.

Figure 4 shows the uniformat is used to process component information consistently. The uniformat is a very strict format, which must be output according to the format given by the Unitechnik specification. Otherwise, the data in the output file cannot be recognized by the machine, the BIM model of the assembly building component can be constructed, and the node family of the steel structure can be constructed with the parameterization idea. Parameterization mainly describes the creation of steel structure node family during the reference plane, and reference line, so high-rise steel structure components are in accordance with the construction requirements. The assembled building components mainly include an H-shaped steel column, square steel column, column base plate, and anchor bolt. The bracing column of a high-rise steel structure is connected with the foundation member, and the bracing column position is adjusted according to the scale requirements. After the connection model of the high-rise steel structure is constructed, the reinforcing steel bars are inserted. In the whole process of connection model construction, the connection parameters are associated with the foundation member, and the center parameters of the structure are selected to control the other parameters. The main rules are as follows:

(1) Each piece of information is described with a fixed lead word, such as “CONTOUR.” Also, each block of information must end with an “END” description.

(2) If the information in some entries is missing or does not need to be output, it needs to be replaced by spaces or underscores corresponding to the number of characters.

Table 2: Building component code table.

Cast-in-place frame		Cast-in-place floor		Cast-in-place shear wall		Cast-in-place floor	
Component type	Component code	Component type	Component code	Component type	Component code	Component type	Component code
Frame column	KZ	Floor panel	LB	Constrained edge member	YBZ	Stair beam	TL
Floor frame beam.	KL	Roof panel	WB	Constrained edge member postpouring section	YHJ	Platform plate	PTB
Roofing frame beam	WKL	Cantilever beam	XB	Postpouring section without concealed column for change member	AZ	Cast-in-place ladder	TB
Secondary liang	L	Concealed beam	AL	Prefabricated external panel	AHJ	Buttress column	FBZ
Cantilever beam	XL	Floor out of horizontal postpouring strip	SHJD	Decorative panel	YGB		
Precast facade	YWQ	Prefabricated floor panel	YB	Prefabricated block	YT		
Precast interior wall	YNQ	Bottom joint of laminated plate	JF				
Precast laminated beam	DL	Prefabricated balcony	YYTB				
Precast exterior formwork	PCF	Prefabricated air-conditioning board	YKTB				
		Prefabricated parapet	YNEQ				

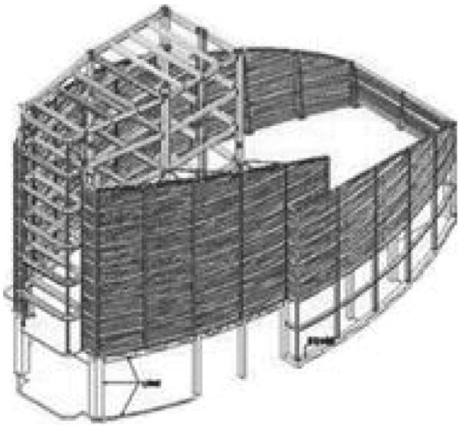

Figure 4: Assembly building component BIM model.

(3) The output of string type information shall be left aligned, and the output of numeric type information shall be right aligned [15].

(4) In order to present more information in fewer bytes, hexadecimal digits are often used in the output of unifiles. For example, the hexadecimal number "ff," converted to a binary number of "1111111111," can be two bytes to represent the parameters of eight Boolean attributes.

The above four rules must be followed, and the component information is of great importance in the process of aided design. Thus, the component information module is optimized [16]. A component information module is a module used to describe the basic information, such as component name, component type, maximum length, maximum width, thickness, assembling, and transportation sequence. This section needs to be obtained from the prefabricated concrete information, which gives an approximate range of prefabricated members and an approximate amount of concrete [17]. Outline information, cutting information, and installation information are all used to describe the specific shape of components, which provide the data of manipulator drawing and swinging in the production process. The contour information is used to describe the basic contour of prefabricated components. Pruning information is used to describe the location of openings such as doors and windows on prefabricated components characterized by the same thickness as the prefabricated components. The installation information is used to describe all the installation parts on the prefabricated member, including the weightlessness plate, wire box, and pipe. Unlike the tailored information, the hole thickness of the installation part can be different from that of the prefabricated member, and the installation height can be certain. Installation information and clipping information are calculated based on contour information.

3.2.1. Calculation of Graded Load of the Steel Structure Frame. The transfer relationship between the upper and lower state variables of the i segment of the BIM model of prefabricated building components is given in the following equation:

$$S_i^a = B_i S_i^b + B_i U_i S_{i-1}^a + H_i S_{i-1}^a. \tag{1}$$

In equation (1), S_i^a and S_i^b represent the state variables of the upper and lower end faces of the structure, S_{i-1}^a represents the state variables of the upper end faces of the $i-1$ segment, B_i and U_i, respectively, represent the transition matrix, and H_i represents the layer transfer matrix in the stability analysis of the high-rise steel structure joint model.

Based on the information and characteristics of each component, a simplified CAD protocol is designed. This agreement is generally divided into three parts: basic information of prefabricated elements, concrete placement information of prefabricated elements, and reinforcement information of prefabricated elements [18]. The basic information of the prefabricated member is used to describe the maximum size of the prefabricated member, and the relationship between the origin of a concrete coordinate system and the origin of the reinforcing steel bar. Assuming that the axial pressure of a single column in the i floor of the steel structure frame of a high-rise member is $P_i = \alpha_i P$, equations (2) and (3) describe the load.

$$P_i \leq P_y, \tag{2}$$

$$P \leq \frac{1}{\alpha_i} P_y = P_e. \tag{3}$$

In equations (2) and (3), P_y is the load corresponding to the yield of high-rise steel structure material, α_i is the maximum value, and P is usually taken in the interval $[0 \sim P_e]$.

According to the equations (2) and (3), the graded load of the steel structure frame can be given to determine the instability of the high-rise steel structure as given in the following equation:

$$\Delta P_j = 0.540\left(P_e - P_0\right), \tag{4}$$

where P_0 is the Euler load.

The concrete pouring information of the prefabricated component is divided into two parts: one is the outline information of the component, which the central control computer can recognize, and the other is the information of the hole caused by the arrangement of the door and window hole and the embedded parts. The central control computer can identify the data used for the arrangement of the junction box and form the hole on the component. In the pouring information of precast concrete, all the coordinates are non-negative. The reinforcing steel bar information of the prefabricated member is also divided into two parts: one is to describe the positioning information of each reinforcing steel bar and each reinforcing steel bar truss in the reinforcing steel bar coordinate system of the prefabricated member, which is used for the manipulator to place reinforcing steel bars, and the other is to describe the reinforcing steel bar processing information of the specific shape of a single reinforcing steel bar, which is used for reinforcing steel bar automatic processing machine to process reinforcing steel bars. The above set of protocols is used to complete the computer-aided design of building components.

3.3. Automatic Assembly Inspection of Building Components.

After deepening the design of prefabricated components, it is necessary to produce the prefabricated components according to the concrete information and steel bar information in the BIM deepening design model. Temporary design conditions, such as demolding, turnover, transportation, hoisting, and installation, exist in prefabricated members during the process from concrete pouring to installation in the building [19]. These conditions are not taken into account in the structural analysis. In order to ensure the safety in the production and transportation of prefabricated members, the temporary conditions of each prefabricated member need to be checked separately. In this design, the automatic assembly inspection of building components is embodied by the checking calculation of the demolding bearing capacity of the composite board.

3.3.1. Calculation of Bearing Capacity and Test Equation.

Before calculating the bearing capacity of the composite plate, the following parameters need to be read from the composite plate, that is, the diameter of the upper chord bar a of the truss. The cross-sectional area A, the diameter a_2 of the bottom chord bar of the truss, and its cross-sectional area A_2, and the cross-sectional area of the truss web member reinforcement A_3, the distance l from the bottom of the composite slab to the centroid of the top chord reinforcement, the distance l_1 from the centroid of the distributed reinforcement in the slab parallel to the truss reinforcement, and the distance l_2 between the centroid of the bottom chord and the top chord reinforcement are calculated as shown in the following equation:

$$\begin{cases} l = g + a_1 + L - l_2 - \dfrac{l_3}{2}, \\ l_1 = l - g - \dfrac{l_1}{2}, \\ l_2 = L - \dfrac{\left(l_1 + l_3\right)}{2}. \end{cases} \tag{5}$$

In equation (5), we set g as the distance between the outer skin of the distributed reinforcement at the bottom of the composite slab and the bottom of the slab; set l_1 as the diameter of the distributed reinforcement parallel to the truss reinforcement; set l as the diameter of the distributed reinforcement in the slab perpendicular to the truss reinforcement; and set L as the outer height of the truss reinforcement. Equation (6) is the integrated equation

$$\begin{cases} l = g + a_1 + L - \dfrac{(l_2 - l_3)}{2}, \\ l_1 = l - g - l - \dfrac{l_1}{2}, \\ l_2 = L - \dfrac{(l_1 + l_3)}{2}. \end{cases} \tag{6}$$

The concrete and steel bars in a distance near a truss are regarded as a composite beam when checking the short-term working conditions of the composite slab. The width F of the composite beam can be given as following equation:

$$F = \sum f_1 + f_2, \tag{7}$$

$$\text{when } f_1 > l_1, f_1 = \left(0.5 - \frac{0.3e}{l1}\right)e, \tag{8}$$

$$f_1 \geq l_1, f_1 = 0.21_1. \tag{9}$$

In equations (8) and (9), f_1 is set as the centroid spacing of bottom chord reinforcement, e is set as the centroid spacing of adjacent truss reinforcement, and l_1 is the clear width of precast composite slab.

According to the equations (7)–(9), we can get the test equation as given in the following equation:

$$u = l - \frac{F * T(l - t/2) + (A_1 L_1 + A_2 L_2)(\beta_1 - 1)}{F * T(A_1 + A_2)(\beta_1 - 1) + A_1 * \beta_1}. \tag{10}$$

In the equation (10), we set A_1 as the area of distributed reinforcement parallel to the truss bar within the range of slab width F and set β_1 as the ratio of the elastic modulus of the reinforcement in the composite beam to the concrete of the composite slab, and t is the thickness of the composite slab. Through equation (10), the automatic detection of component design results is completed.

BIM model contains abundant information of components and their hoisting and embedding parts. The checking calculation of short working conditions of prefabricated components based on BIM can be directly extracted from the deepening design model [20]. Therefore, this chapter combines the structural design specifications and structural construction specifications for the GB Atlas of overlapping panels and prefabricated walls for a short time period check. When the check results are not satisfied can be reminded in the program, designers need to redesign or embed parts design. In addition, it can directly generate the calculation book of short working conditions of prefabricated components, which can be used for delivery. This tedious and complicated work can be realized with one key in the software, which can significantly improve the design efficiency of designers in assembling concrete buildings and the accuracy of the calculation of short working conditions.

4. Results

4.1. System Test Environment. In order to prove the validity of the cost evaluation model of a high-rise building project based on a BP neural network, 10 completed high-rise building projects are selected, and the sample data are all from the cost information network. The acquired data are preprocessed in combination with the quantitative criteria for qualitative indicators, and the selected sample data indicator values are shown in Table 3.

According to this paper's neural network evaluation model, simulation experiments are carried out based on MATLAB 2016b software. Because the assembly building component automation system based on BIM technology does not require high hardware and software configuration of the computer system, it can be tested in a conventional stand-alone system. The system test environment is shown in Table 4.

4.2. Comparison Results of Evaluation Error Rate and Speed of Different System Components. The information node equipment is introduced into the system test platform, and the platform is used as the hardware foundation to realize the system test. By comparing the design system and other two systems in the form of the use of results, we complete the system test. The simulation results are compared with the proposed model in [2, 3] systems. The comparison results are shown in Table 5.

From the results in Table 2, we can see that the error rates of the system in [2] and the system in [3] are 16.9% and 16.7%, respectively. Compared with the system in [2] and in [3], proposed system error rates are lower, and the error rate is controlled within 10%, which meets the requirements of the assembly building components. In addition, three system evaluation speeds are compared, and the results are shown in Figure 5.

From Figure 5, we can see that the time required for automation components of the system in [2] and the system in [3] for 10 components is 0.6 s and 0.45 s, respectively. Compared with the system in [2] and in [3], proposed system time are lower, and the time is within 0.15 s, which means speed of proposed system meets the requirements of the assembly building components and is better than existing system.

Compared with the [2, 3] system literature, the speed of the automation component in this system takes less time, and the efficiency of the automation component is higher in the same target. The main reason is that the BIM data are organized according to a specific format. The machine identifies the data and then arranges the production of the prefabricated components to reduce the time and increase the speed of the components.

4.3. Design System Strength Test. In order to test the adaptability of the system to buildings with different levels of complexity, different buildings are used for testing. As shown in Table 6, 3 different building type test cases are used

Table 3: Engineering characteristic index values.

Serial number	Floor space	Layer number	Doors and windows	Height of eaves	Structural type	Erection works
1	1	18	2	54.1	1	4
2	2	20	6	59.6	1	4
3	2	24	2	87.6	1	3
4	1	19	4	92.3	2	2
5	2	25	3	89.5	2	1
6	2	23	2	87.2	1	4
7	2	19	1	74.8	1	2
8	1	18	5	94.2	3	3
9	1	24	2	84.1	1	4
10	2	25	3	87.6	1	2

Table 4: System test environment.

Direction of use	Device name	Model parameter
Hardware section	CPU	Pentium C Dual-Core CPU E6500 (2.93 GHz)
	Chipset	Intel 4 Series Chipset
	Memory	2G (2.93 GHz)
	Hard disk	500G
Software component	OS	Microsoft XP Professional SP3
	Graphic environment	AutoCAD 2010
	Database system	SQL Server 2008

Table 5: Error rate results of evaluation of different system components.

System	Actual value (yuan/m^2)	Predictive value (yuan/m^2)	Error value (yuan/m^2)	Error rate (%)
References [2]system	1525.2	1835.2	310	16.9
References [3]system	1541.3	1848.2	306.9	16.7
System of paper	1428.6	1521.8	93.2	6.1

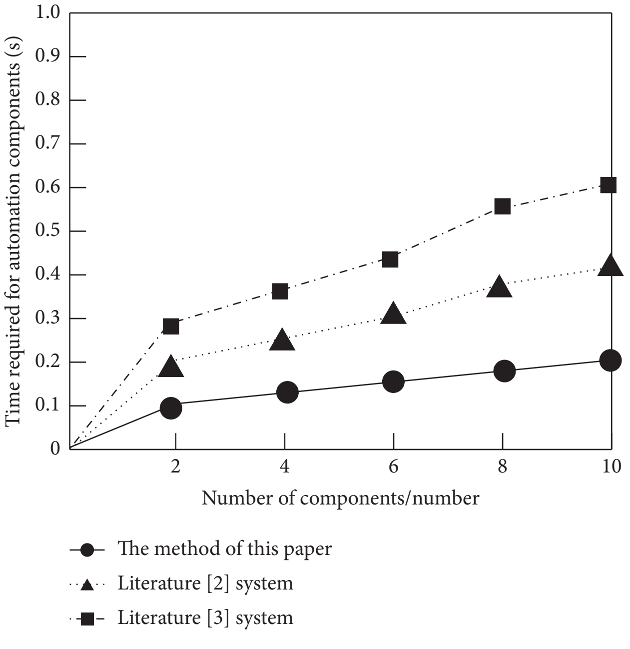

Figure 5: Speed comparison diagram of components of different systems.

to carry out the contrast test with the overall building refresh time as the indicator.

Through the above test results, the design system can be used to automate many kinds of building components, meet the requirements of comparison with other components, and can carry out contrast tests. In the automation processing of the same building, the design time of the component is close to the detection time of the component, and the response time of the design system is short. In conclusion, the design system in this paper has the best effect. Assembly building is the key development direction of the future construction project, and the component automation system is of great significance to the investment of this project.

5. Discussion

BIM and assembly architecture represent the development direction of the construction industry. At present, the informatization level is not high, the management system is backward, the production efficiency is low, and advanced technology and management concept are urgently needed. Based on computer-integrated manufacturing, BIM technology, and assembly building construction, this paper puts forward the assembly building component automation system based on BIM technology. The research work of this paper and the innovative achievements are as follows:

(1) Based on the comparison and induction of manufacturing industry and assembly building, the concept of assembly building component automation system based on BIM technology is put forward

Table 6: Results of system strength tests.

Numbering	Types of architecture	Quantitative characteristics			System refresh time	Is the expected result achieved	Remarks
		Number of walls	Number of doors and windows	Number of floors			
1	Unit model	100	1456	30	3 minutes	Yes	Flat dwelling
2	Multi-element model	450	4498	60	7 minutes	Yes	Multi-unit dwelling
3	Complex model	17854	5578	155	30 minutes	Yes	An annex to a large hotel

based on computer-integrated manufacturing and BIM technology.

(2) Based on the analysis of the mature architecture of computer-integrated manufacturing system and the assembly architecture characteristics, the overall hardware design framework is studied and put forward.

(3) Based on the overall hardware framework, the composition of the automatic subsystem and the supporting system is proposed. The design idea, functional framework, and design principle of each subsystem and support system are expounded.

(4) After designing all kinds of prefabricated components, hoisting and checking of the component is done under a special checking and calculating menu, which generates the checking and calculating book, which has reference significance in hoisting and transporting prefabricated components. The prefabricated shear wall, prefabricated column, prefabricated beam, prefabricated overlay board, and prefabricated staircase are stored in the prefabricated component library after the design calculation is completed and the parametric management is carried out. The prefabricated components stored in the prefabricated component library can be retrieved and used at any time, thus saving the design cost.

BIM technology and assembly building are of great significance to the development of the construction industry but are also the hot spot of industry research and application. The research in this paper draws attention to how better to apply BIM technology in the assembly construction project, and we believe that there will be better research results in the future.

6. Conclusions

From the perspective of market development, housing industrialization as a new industry, it is imperative to test the buildings in a simulated environment with respect to their structure for resistance to earthquake and for sustainable energy. The proposed method will enable design teams to strike a proper balance between economic, social, and environmental concerns by altering the ways of project development. This paper focuses on the use of software to analyze the project's structure with respect to many factors such as stability, resistance to earthquake, and energy consumption. Structural analysis software is used which makes the structural analysis results and prefabricated component design simple enough to find a variety of prefabricated component splitting methods in the future research. The simulation result of proposed theoretical system gives better accuracy over the existing system for automation of components designing. In this paper, BIM technology is used to solve some problems in the automation process of assembly building components, which provides a reference for future research. However, the article still has some limitations, which need further study by considering more factors that impact the environment. This paper discusses the design of the automatic processing configuration management platform for assembly building components conceptually. However, the implementation of the software still needs certain computer programming ability for analyzing the impact of building development on the environment to save energy and to reduce carbon emissions.

Data Availability

All the data pertaining to this article are available in the article.

Conflicts of Interest

The authors declared that they have no conflicts of interest regarding the publication of this paper.

References

[1] F. Cen, D. Yang, and M. Li, "Application of the building information model in the design of marine architectural structures," *Journal of Coastal Research*, vol. 98, no. sp1, p. 255, 2019.

[2] F. S. Bataglin, D. D. Viana, C. T. Formoso, and I. R. Bulhões, "Model for planning and controlling the delivery and assembly of engineer-to-order prefabricated building systems: exploring synergies between Lean and BIM," *Canadian Journal of Civil Engineering*, vol. 47, no. 2, pp. 165–177, 2020.

[3] X. Ren, W. Fan, J. Li, and J. Chen, "Building Information Model-based finite element analysis of high-rise building community subjected to extreme earthquakes," *Advances in Structural Engineering*, vol. 22, no. 4, pp. 971–981, 2019.

[4] L. Jiang, S. R. Sakhare, and M. Kaur, "Impact of industrial 4.0 on environment along with correlation between economic growth and carbon emissions," *International Journal of System Assurance Engineering and Management*, vol. 13, no. S1, pp. 415–423, 2021.

[5] G. Zhanglin, G. Si, and L. Jun-e, “Application of BIM technology in prefabricated buildings,” *IOP Conference Series: Earth and Environmental Science*, vol. 81, no. 1, p. 012139, 2017.

[6] M. Kaur and S. Kadam, “Bio-inspired workflow scheduling on HPC platforms,” *Tehnički glasnik*, vol. 15, no. 1, pp. 60–68, 2021.

[7] M. Kaur, A. Jadhav, and F. Akter, “Resource selection from edge-cloud for IIoT and blockchain-based applications in industry 4.0/5.0,” *Security and Communication Networks*, vol. 2022, Article ID 9314052, 2022.

[8] A. Jadhav, M. Kaur, and F. Akter, “Evolution of software development effort and cost estimation techniques: five decades study using automated text mining approach,” *Mathematical Problems in Engineering*, vol. 2022, pp. 1–17, Article ID 5782587, 2022.

[9] W. Ferdous, Y. Bai, T. D. Ngo, A. Manalo, and P. Mendis, “New advancements, challenges and opportunities of multi-storey modular buildings-a state-of-the-art review,” *Engineering Structures*, vol. 183, pp. 883–893, 2019.

[10] Y. A. Alvarado, M. Buitrago, I. Gasch, C. A. Prieto, and Y. A. Ardila, “Stage of construction: an essential consideration in designing reinforced concrete building structures,” *Structural Concrete*, vol. 19, no. 6, pp. 1551–1559, 2018.

[11] B. Paramasivam, S. Dashti, and A. Liel, “Influence of prefabricated vertical drains on the seismic performance of structures founded on liquefiable soils,” *Journal of Geotechnical and Geoenvironmental Engineering*, vol. 144, no. 10, 04018070 pages, 2018.

[12] R. Landolfo, O. Iuorio, and L. Fiorino, “Experimental seismic performance evaluation of modular lightweight steel buildings within the ELISSA project,” *Earthquake Engineering & Structural Dynamics*, vol. 47, no. 15, pp. 2921–2943, 2018.

[13] A. Groenewolt, T. Schwinn, L. Nguyen, and A. Menges, “An interactive agent-based framework for materialization-informed architectural design,” *Swarm Intelligence*, vol. 12, no. 2, pp. 155–186, 2018.

[14] D. C. Anderson, S. A. Pang, D. O’Neill, and E. A. Edelstein, “The convergence of architectural design and health,” *The Lancet*, vol. 392, no. 10163, pp. 2432-2433, 2018.

[15] K. Mansfield, “Architectural lighting design: a research review over 50 years,” *Lighting Research and Technology*, vol. 50, no. 1, pp. 80–97, 2018.

[16] H. V. Burton and G. G. Deierlein, “Integrating visual damage simulation, virtual inspection, and collapse capacity to evaluate post-earthquake structural safety of buildings,” *Earthquake Engineering & Structural Dynamics*, vol. 47, no. 2, pp. 294–310, 2018.

[17] N. Sebaibi and M. Boutouil, “Reducing energy consumption of prefabricated building elements and lowering the environmental impact of concrete,” *Engineering Structures*, vol. 213110594 pages, 2020.

[18] Y. F. Zhang and L. Wang, “Simulation of bearing capacity prediction of stratum in urban building,” *Computer Simulation*, vol. 35, no. 2, pp. 450–454, 2018.

[19] M. I. Monowar, S. R. Shakil, A. H. Kafi, and M. K. Rhaman, “Framework of an intelligent, multi nodal and secured RF based wireless home automation system for multifunctional devices,” *Wireless Personal Communications*, vol. 105, no. 1, pp. 1–16, 2019.

[20] R. Bortolini, C. T. Formoso, and D. D. Viana, “Site logistics planning and control for engineer-to-order prefabricated building systems using BIM 4D modeling,” *Automation in Construction*, vol. 98, pp. 248–264, 2019.