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Article

Application analysis of biomechanics-driven energy-saving design of residential buildings based on BIM technology

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Abstract: Aiming at the problems existing in the water supply and drainage design of high-rise buildings, this paper starts with the application advantages and design process of BIM technology in the water supply and drainage design of high-rise buildings. Suggestions for promoting the sustainable development of science and technology are put forward for the reference of relevant persons in charge. In the architectural design industry, architectural design is not only a literary and artistic creation, but also a comprehensive engineering project involving multiple industries. It mainly contains a large amount of information, which must be collected, classified, analyzed, searched and transmitted by powerful technical means. Building information entity model BIM technology is a new concept, new concept and new technology existing in data building technology, which brings a strong technical support point for the development trend of building customization. This paper discusses the energy - saving design application of this small high-rise residence based on BIM technology. This paper also integrates the principles of biomechanics and biomimicry to further enhance the application of BIM technology in green energy-saving design. By simulating biological structures and ecosystems in nature, it optimizes the building's energy management and structural performance, thereby designing more efficient and sustainable architectural solutions.

Keywords: BIM technology; small high-rise residential buildings; application of energy-saving design scheme

1. Introduction

In recent years, the development of China's economy, society and economy has well promoted the continuous growth of the construction engineering industry. Especially for small and medium-sized high-rise residences, with the increase of urban population, the development of small and medium-sized high-rise residences in terms of comfort, environmental protection, aesthetics and other intelligent and intelligent aspects is becoming more and more complicated. modern aspect. BIM technology is developed according to the current situation in this field. Its application in construction not only greatly reduces the workload of designers, but also reduces the quality and efficiency of architectural customization. The following briefly analyzes and discusses the practical application of BIM technology and high-rise residential customization. With the steady growth of the population and the rapid development of the economy, the country's demand for housing and construction has not decreased, and the problem of energy consumption in the construction industry has become increasingly prominent. Energy saving has become one of the important tasks of building energy saving. However, in the traditional construction process, energy saving issues are often ignored subjectively or objectively [1]. BIM technology is a new type of technology, which can realize building energy-saving

design scheme, building information collection, and energy-saving index analysis of building and surrounding environment. According to new technologies and simulation tools, green and energy-saving high-rise residential design can be realized.

2. BIM technology and green building concept

2.1. BIM technology concept

BIM technology has many definitions. From the perspective of architectural design, this paper applies technology to the construction and application of building information model, including energy-saving index analysis and energy-saving information management methods. Always build information modeling software for manufacturing data [2]. Combined with the advantages of the new project itself, with the help of BIM technology, a data visualization database system for building interconnection has been established. Based on the virtual building information entity model, this technology can analyze and efficiently manage the energy saving of the whole life cycle of the building, and then conduct more professional design function tests. The ideal state of BIM technology is to achieve integrity and flexibility in all construction processes, with the entire building life cycle as operational cycle time. At present, the technology is in the design stage, and no matter the depth or scope of the application, more new projects are needed to realize the diversified development trend of technology and business (William Shakespeare, Northern Expert). BIM technology has greatly enhanced architectural design efficiency and accuracy. By creating a centralized 3D model, BIM enables multidisciplinary teams (architecture, structural, MEP) to collaborate on a single platform, reducing information silos, avoiding design conflicts, and minimizing redundant work. This integrated approach accelerates design timelines, improves quality, and facilitates smooth communication, thereby decreasing design errors. Additionally, BIM supports energy-efficient design through early-stage energy simulations and analyses. Designers can evaluate a building's energy performance, optimize its shape, material selection, and equipment configuration to boost energy efficiency. BIM also aids in designing natural lighting and ventilation, reducing reliance on artificial systems and lowering energy consumption. During construction, BIM helps identify potential issues and optimize processes, minimizing energy waste. Furthermore, BIM lifecycle management allows continuous monitoring and optimization of energy use during the building's operation, promoting sustainable and green building development.

2.2. Specific operations

In the process of architectural design, BIM technology generally uses CAD technology to describe the overall status of the construction project and data representation at different stages, and the data storage generally adopts the method of electronic equipment model. These storage methods are very convenient for future data calculation, data information adjustment, and data reading.

2.3. Application characteristics of BIM technology

Architects use BIM technology in construction engineering design, and use construction drawing design in construction engineering, operation, use, decision-making stage, construction acceptance link, sales stage, application maintenance stage, etc. The organizational structure of the BIM center is shown in **Figure 1**. For the first time, CAD technology is applied to architectural engineering design, and the 3D rendering of the design scheme is more visualized, which fully reflects the architectural characteristics of the building. The application of BIM technology in architectural engineering design will further improve the design efficiency of designers in the design of architectural engineering projects. Using the electronic resource file format to store architectural design scheme information can not only share the information in the design scene, but also modify the scene (Peter Burt, American TV Series, Design Scheme).

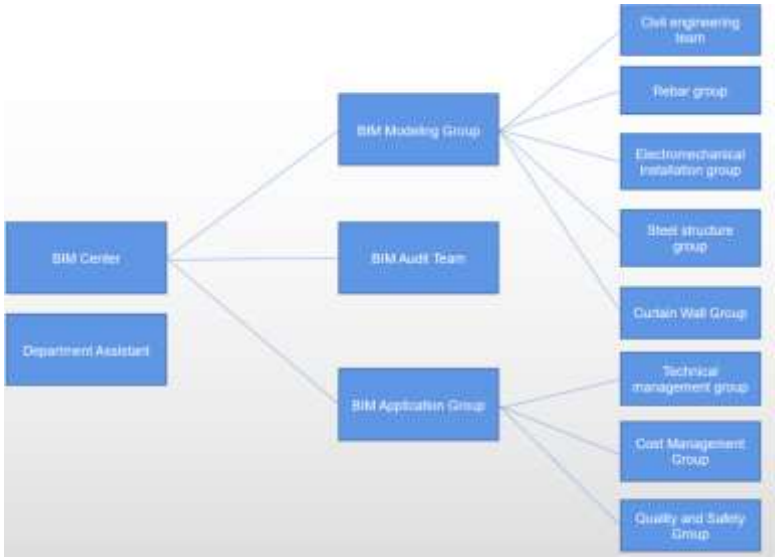

Figure 1. BIM center organizational structure.

In practical operations, CAD tools are first used to create two-dimensional drawings, defining the building's basic floor layout and construction details. Subsequently, BIM software such as Revit is utilized to convert these two-dimensional drawings into three-dimensional models. Throughout this process, designers can visually inspect various parts of the building and make real-time modifications. For example, using BIM's parametric design features, adjustments to wall thicknesses, window sizes, and other elements automatically update the corresponding views and drawings. BIM technology integrates various building data, including material specifications, structural loads, and energy performance, allowing designers to import this data through CAD tools for detailed analysis and optimization. For instance, by employing BIM's built-in energy simulation tools, designers can evaluate the energy efficiency of different design schemes and select the optimal option. Additionally, BIM supports clash detection by visualizing the interfaces between different disciplines through CAD models, enabling the early identification and resolution of potential design conflicts to ensure a smooth construction process.

2.4. Green energy-saving design of buildings

Biomechanics optimizes structural design by simulating the mechanical characteristics of biological structures in nature, enhancing building stability and energy utilization efficiency. For example, by emulating the support structures of trees, energy-efficient building frameworks can be designed to reduce material usage while increasing building resilience [3]. Biology, through biomimetic approaches, designs building functions similar to natural ecosystems, such as natural ventilation, passive lighting, and rainwater harvesting systems, thereby reducing dependence on artificial energy sources and lowering energy consumption and environmental impact. Green building energy-efficient design should prioritize energy analysis factors based on local climate, geographical location, and biodiversity, and combine innovative applications of biomechanics and biology to develop efficient energy-saving and emission-reduction strategies. Specific distribution characteristics are shown in **Table 1**.

Table 1. Distribution of BIM architectural design employment.

1. Great demand	According to the investigation and design of the relevant departments, the construction. The shortage of talents in architectural design, industrial design, and product design is very large, and enterprises are eager for talents.
2. High salary	The starting salary of graduates in architectural design, industrial design, product design and other majors is about 3000–4000 yuan, and the annual salary of outstanding employees in most enterprises is generally more than 100,000 yuan.
3. Wide range of employment	After graduation, students majoring in architectural design and industrial design generally work in the design, research and development, new product development and other departments of enterprises. They have high technical content, comfortable working environment, and relatively high salaries. Students can also set up their own design companies. Design studios can also work in relevant departments such as local governments, universities, and institutions.

Beijing FCD Center exemplifies a green high-rise residential building that fully leverages BIM technology for exceptional energy-efficient design. Covering 50,000 square meters across 30 floors, it utilizes a double-skin façade and high-efficiency insulating materials to minimize heat loss in winter and reduce heat gain in summer. BIM-based simulations enabled the design team to optimize building orientation and window layout, maximizing natural lighting and ventilation, which significantly lowers energy consumption for lighting and air conditioning. The FCD Center is equipped with 5000 square meters of solar photovoltaic panels, generating an estimated 80,000 kilowatt-hours annually, meeting about 15% of its electricity demand. Additionally, intelligent lighting control systems and high-efficiency energy-saving elevators are integrated through BIM technology, allowing dynamic monitoring and optimal energy scheduling to enhance overall efficiency. Water resource management is a key focus, with rainwater collection and greywater recycling systems reclaiming approximately 200 tons of rainwater annually for landscape irrigation and facility flushing, thereby reducing municipal water consumption. BIM plays a crucial role in optimizing pipe layout design, ensuring efficient and scientifically sound pipeline systems while preventing resource waste and potential conflicts. High-efficiency building envelopes and green roofs not only enhance the building's aesthetic appeal but also improve its insulating performance. Through BIM-enabled full lifecycle management—from design and construction to

operation and maintenance—the FCD Center ensures the effective implementation and continuous optimization of its green and energy-efficient measures. This project demonstrates BIM technology's vast potential in sustainable high-rise residential design, providing valuable insights for future energy-efficient buildings.

3. Status quo of building green energy-saving design based on BIM technology

3.1. Advantages of applying BIM technology in energy-saving design of high-rise residential buildings

3.1.1. One-click generation of data information text documents and design drawings by BIM technology

Before the invention and application of BIM technology, the type, integration and modification of data information text files and design drawings were all done manually. Employees encounter time-consuming and complex work tasks. If the key points change, the overall architecture design also needs to change accordingly. This kind of thing has been greatly improved after using BIM technology to assist in the design of building energy-saving design schemes. BIM has gradually entered people's lives, and the specific presentation form is shown in **Figure 2**. The system software Generates all relevant information and text document design drawings with one click, and uploads them to the mobile client. In addition to these advantages, the architect's 3D scene design can also be carried out through the produced BIM. This greatly simplifies and effectively manages method and process changes in graphic design [4].

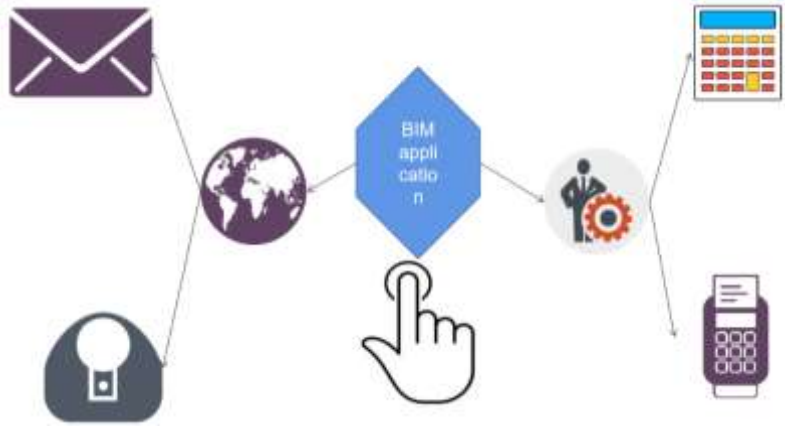

Figure 2. The application of BIM in daily life.

3.1.2. BIM technology can analyze systems and process building data information, and the environment that BIM can build refers to virtual equipment

Employees transfer the data of small and medium-sized high-rise residential buildings to the BIM entity model, the system will generate a comprehensive performance plan with one click, and use the data analysis system to process and observe the relevant building data information. According to BIM technology,

architectural interior designers can complete the multi-dimensional observation of details enhances the three-dimensional and layered sense of customization, and gives resource advantages to the most detailed interior space design. The specific processing method is shown in **Figure 3** [5]. Architectural interior designers can flexibly use the virtual data processing method (a unique function of BIM technology), and after completing the association of building information in the database system, automatically compare the design drawings with the statistical data, and clearly grasp the construction data and statistical data. data. Differences between specific cost budgets and complete with correct management methods.

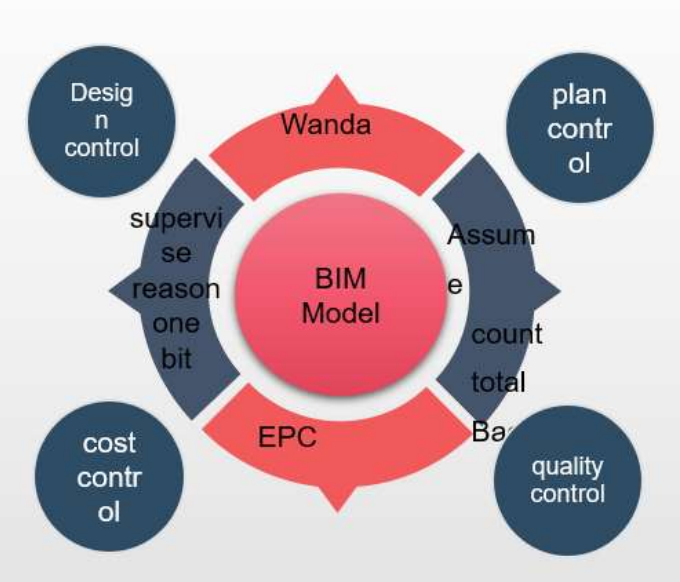

Figure 3. Process flow of BIM in architectural design.

3.1.3. BIM technology automatically changes and optimizes data information

In architectural design, the management approach must cover all aspects. Each link is very closely integrated, so the scientific level of the whole process lies in the scientific rationalization of each process. If partial propagation fails, the information needs to be re-compared. Solid model solving technology is the main feature of BIM technology. Interior designers can use this technology to systematize the conclusion of the design scheme, quickly find problems in the design scheme, and make adjustments and changes efficiently. The information of BIM information system software is not independent, but coexists with organic chemistry [6]. Therefore, when the data information changes, the statistical data will be automatically adjusted, which greatly simplifies the whole process of building customization changes and optimization.

3.2. The necessity of BIM technology for green buildings

Combine the energy-saving information features of the architectural design process with the architectural model design, generate a three-dimensional visual energy-saving entity model with information, and carry out energy-saving design plans in accordance with national standards. According to the simulation analysis of the building model, the energy consumption of the building is obtained. First, when

acquiring data, information such as thickness of building raw materials, fire resistance and other information of new construction projects is aggregated to generate structural characteristics of thermal bridges and cold bridges. Generate an information management method, database system, and endow the viability of the energy consumption level of the virtual building integrity design scheme [7]. Information such as building characteristic parameters is a part of the building, and the building design scheme is given to provide better management for the whole life cycle of the building.

3.3. Application of BIM technology in green energy-saving design scheme

In building green energy-saving design, BIM technology defines the informatization level and new projects of energy-saving models according to my country's building information entity model standards and building information transmission specifications, and uses BIM technology-specific tools to create building green energy-saving information entity models. It is stipulated that after the general building green energy saving information database system has passed the database security and accuracy certification, the energy saving software analysis function of BIM technology will be used to simulate building energy saving. BIM-based building design can calculate economic efficiency. The specific calculation is shown in **Table 2**. Prepare numerical and data analysis reports, optimize and improve according to the specification limits, and finally compare and select the actual energy-saving scheme design of the building, and deliver the project to the construction, operation and maintenance stages to ensure that the low-energy building operates efficiently during its life cycle.

Table 2. Calculation of China's BIM market capacity in 2020.

serial number	plate	project	unit price	predict
1	R & D market	Special first-class enterprises: 9604	2 million/home	About 20 billion yuan
2	Consulting the market	New construction area: 2.027 billion square meters	10–25 yuan/m^2	20–50 billion yuan
3	training market	50 million employees in the construction industry	100–200 yuan/person	5–10 billion yuan
4	Operation and maintenance market	Construction area: 60 billion square meters	5 yuan/m^2	About 180 billion yuan
total				225–260 billion yuan

3.4. High-rise residential design and planning

3.4.1. Small high-rise residential background

Generally speaking, the architectural space features are reflected in the surrounding garden landscape, house shape, traffic flow and so on. BIM technology is applied to architectural interior space design, using the three-dimensional visual function of BIM data and the corresponding terrain analysis method to comprehensively design the appearance model, traffic flow line and surrounding garden landscape of small and medium-sized high-rise residential buildings [8]. For the first time on the construction site Conduct in-depth investigations, apply relevant analysis software to analyze soil fluctuations, the structure and internal strength of small high-rise residential construction sites, and the volume of the interior space of

the building, formulate a design plan for the exterior space of the building, and create a three-dimensional information solid model. With the continuous development of the application space of small high-rise residential buildings, the engineering quality of small high-rise residential buildings is limited by external conditions. Quality of life is very common these days and there are more and more regulations on housing. For example, when applying REVIT to the design of small high-rise residential buildings, it is necessary to understand the surrounding buildings, geological conditions and vegetation distribution of small high-rise residential buildings, including geological environment, rock distribution, building distribution, greening, etc. environment, etc. The data is then analyzed through REVIT tools to simulate the surrounding environment, including climatic conditions, lighting effects and noise. Through simulation analysis, the lightning protection effect, lighting effect and earthquake resistance effect of small high-rise residential buildings are mastered [9]. When designing small high-rise residential buildings, designers can consider the possible strong wind, rain and snow and dry climate according to dynamic simulation conditions, so as to design corresponding shading design, heating design, etc., to provide users with a stable, comfortable and comfortable living environment. Safe living environment. The specific design framework is shown in **Figure 4**.

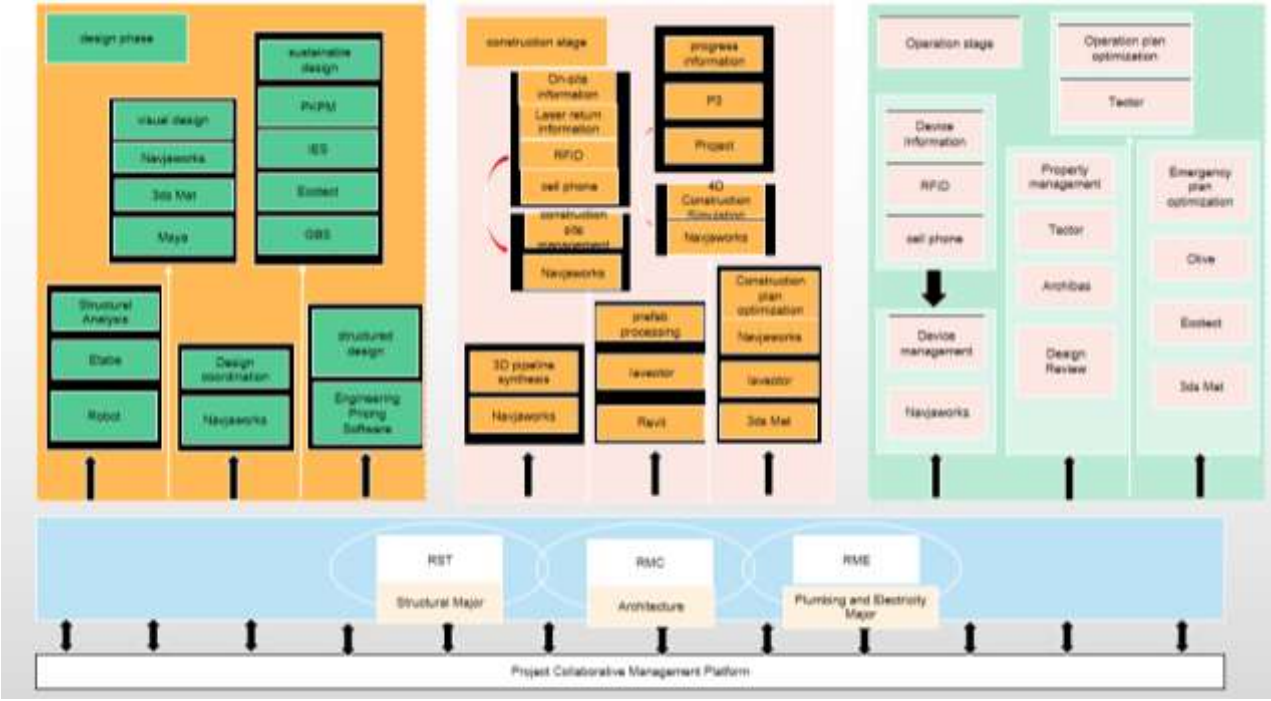

Figure 4. BIM technical framework.

3.4.2. Create green buildings and reduce building energy consumption

One-sided emphasis on social and economic development can easily lead to air pollution. This is a serious problem in the current development trend of our country. Therefore, my country has put forward the corresponding concept of my country's innovation and development. In order to adapt to this core concept, construction companies must reflect the core concepts of environmental protection, energy saving, environmental protection, low carbon environmental protection and other core

concepts when designing residential buildings [10]. The use of BIM technology in the architectural design of small and medium-sized high-rise buildings must give full play to the environmental protection and energy saving effects of buildings. In the environmental protection and energy saving design of small and medium-sized high-rise buildings, the BIM method is applied, starting from three aspects. It is the collective environmental protection and energy saving of the building. It is necessary to integrate relevant information and data inside and outside the building, and then use a special process model to simulate the energy-saving system of the building's circulation system, and then use solar energy, wind energy and other clean energy to save energy and reduce emissions. The energy stored in the wall and the ambient temperature of the building landscape. Second, the overall layout of the building is environmentally friendly and energy-saving. The designer should use the analysis system to analyze the building information data information, make full use of the functions of the analysis system, predict and analyze the specific internal and external natural environment of the building, adjust the architectural plan in the architectural design link, and complete the environmental protection and energy saving of the building. In the end, the building is basically overall planned and designed to be both environmentally friendly and energy efficient. This building energy saving method mainly uses the building environment to save energy, and uses analysis software to analyze the building environment. For example, in the design and application of small and high-rise residential buildings, building materials and energy consumption can be designed through sustainable design concepts in BIM technology. In the design process, attention should be paid to the protection of the surrounding architectural environment of the residence, and some green building materials should be selected to reduce environmental pollution. Corresponding ventilation design can be set to use natural wind for ventilation and cooling treatment to reduce the harm of air conditioning to the human body. In the lighting simulation design, attention should be paid to the design of light heat, low energy consumption, solar energy and automatic modes to provide more convenient lighting modes for residential users. It can be concluded that BIM plays an important role in green building design, and the specific values are shown in **Table 3**.

Table 3. The value of BIM in high-rise building design.

value one	**Accelerate the construction period and greatly reduce the financing cost**
value two	Improve the quality of construction products and increase the price of products
value three	Form a model to improve operation and maintenance efficiency and greatly reduce operation and maintenance costs
value four	Effective control of cost and investment
value five	Improve project coordination ability
value six	Accumulate project data

3.4.3. Architectural model building design and production

When building a solid model of a building, the solid model component is. BIM technology is applied to construction engineering, replacing the solid model components of the building model with the corresponding digital codes, and

transforming the initial data model into a three-dimensional model. At this stage, most models are created using BIM design and building information parametric design techniques. The key of this technology is to segment the clarity area (such as mark clarity, main view clarity, etc.). It can be seen that the development of BIM is inseparable from the help of other software. The specific performance is shown in **Figure 5** [11]. For example, when building a solid model of a small and medium-sized high-rise building, it is necessary to define areas for segmentation, and then set the corresponding main parameters (such as clarity material, structure, structure, facade, etc.) for each definition. After designing the main parameters, change the main parameters according to the specific conditions of small high-rise residential buildings

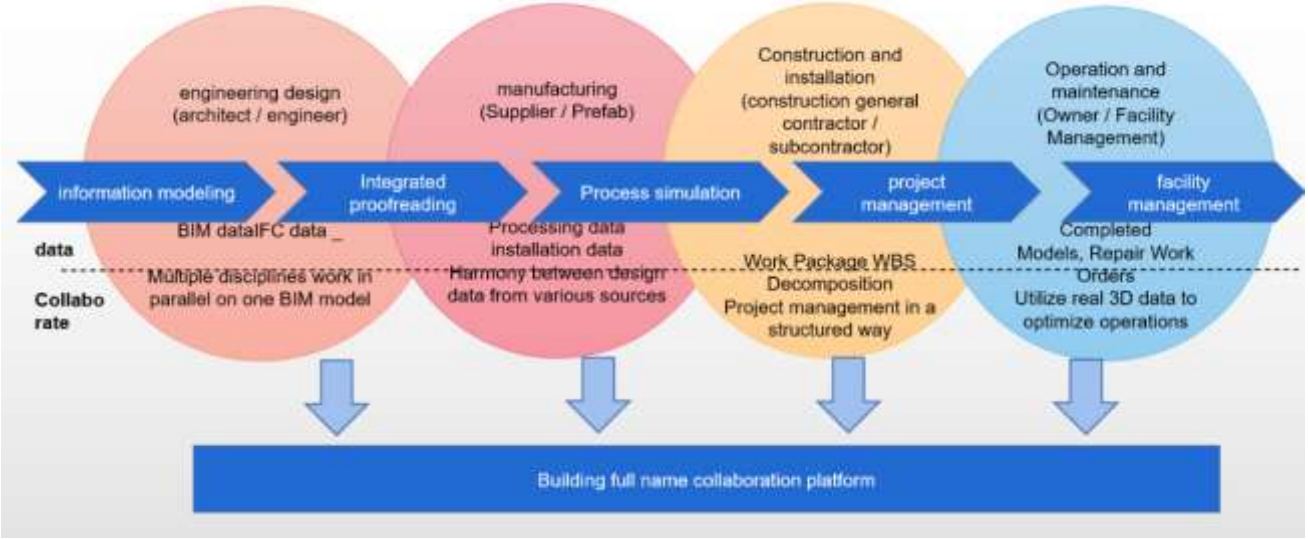

Figure 5. Combination of BIM and other technologies.

The parameters form comprehensive information of small high-rise residential buildings, such as roof plans, 3D maps, etc. Sectional drawings of houses and buildings. It can display information about each graph in detail and display it using graph size, marker, load, text, etc. Small high-rise residential buildings can be displayed more clearly and directly, so that the buildings of small high-rise residential buildings have the visual impact of real life and ensure the quality of the building.

3.4.4. Pipeline layout optimization

Such as construction engineering pipelines, power engineering, heating, drainage pipelines for effective distribution in the middle and late stages. According to the theoretical knowledge of national assembly integration, a BIM model is established to conduct crash tests. In the event of a collision, the engineering construction is conducive to fire evacuation, and the small pipeline follows the principle of large pipeline production. According to the anticipation and handling of the problem, make preparations for installation, improve the pipeline layout plan, and make the installation rational and rational [12].

BIM technology has many advantages such as data visualization, adjustment, simulation, and print output. It is widely used in power supply design of construction

engineering and high-rise residential building engineering. The team has better control over the quality of the project. Designers can use the BIM software system to share the data and information of the BIM model with the construction team, and gradually improve and modify the solid model according to the actual situation. In order to avoid frequent changes to design drawings during on-site construction, the high efficiency of building construction is endangered.

BIM uses the following formula:

1) Boolean operators “and”, “or”, “not”

$$\text{if (and (length = 1000, width = 2000), 1500, length)} \quad (1)$$

2) Other calculation formulas:

In Revit, use integers. For example, the number of blades in our blinds depends on the height of the window. How to create an integer number of blades from an array must use the following formula:

Rounding: round (X);

Such as round (12.3) = 12;

rounds (4.5) = 5;

Rounds (−7.8) = −8(2);

Roundup: Roundup (X);

Roundup (3) = 3;

Summary (4.2) = 5;

Roundup (−3.8) = −3;

Down: round up (X);

rounds (3) = 3;

rounds (3.7) = 3;

rounds (−3.7) = −4(3).

3) Residential building formula

Area = effective area + structural area = usable area + auxiliary area + structural area = structural area + auxiliary area + use area in the set (2)

4) Calculation formula for flat field

$$S = (A + 4) \times (B + 4) = S \text{ bottom} + 2L \text{ outer} + 16.$$

In the formula:

S——site leveling engineering quantity; A——the length of the outer wall of the building in the length direction; B——the length of the outer wall of the building in the width direction; S bottom——the floor area of the building; Outside L—the perimeter of the outer edge of the building’s exterior wall (3)

In the process of pipeline layout optimization, BIM technology achieves precise design and efficient management through various formulas. Firstly, Boolean operators “AND”, “OR”, and “NOT” are used to determine the connection

relationships between pipes. For example, when deciding whether two pipe segments need to intersect, the "AND" operator can be applied to simultaneously satisfy both length and width conditions, thereby determining whether to connect them. This logical assessment helps designers avoid pipe conflicts and enhances the rationality of the layout. Secondly, rounding, ceiling, and floor functions are employed in practical applications to ensure that the quantities of all pipes and equipment are whole numbers. For instance, when determining the number of slats for blinds based on window height, the rounding function is used to convert the calculated result to the nearest integer, preventing partial slats and ensuring the feasibility and aesthetics of the design. In calculating the residential building area, formulas such as "usable area plus structural area" assist designers in accurately estimating the total building area. This enables the rational planning of pipe layouts, ensuring the coverage and efficiency of the piping system. Additionally, the engineering quantity calculation formula for flat sites, which considers the length of exterior walls and floor area, helps determine the amount of construction required for site leveling. This optimizes the pipeline laying paths and reduces resource waste.

4. The application advantages of BIM technology

4.1. The specific advantages of BIM

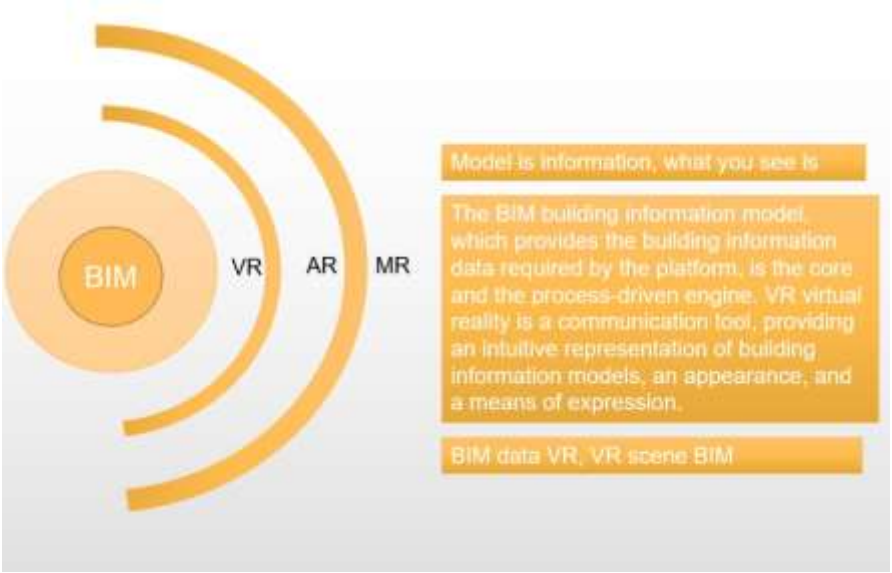

Figure 6. Advantages of BIM.

The BIM software system is suitable for the collaborative application of interdisciplinary authoritative experts. For high-rise residential water supply and drainage design, the architect first creates a 3D model according to the structural parameters of the construction project, and then has other authoritative experts (water supply and drainage design, exhaust pipe design, weak current installation design, etc.). Optimize various network resources, establish and improve the architectural design style, ensure that the individual project design of all projects is rigorous and reasonable, and ensure that each project is on a unified axis. For the water supply and drainage design of high-rise residential buildings, the designer can

immediately integrate all the information required for the water supply and drainage project into the 3D model information database system. Depending on the design, specialized information such as centrifugal pump size and energy consumption must be loaded. Reduce the communication cost between employees and improve the efficiency of collaborative design. The specific advantages of BIM are shown in **Figure 6** [13].

4.2. Advantages of 3D modeling with BIM technology

The 3D model based on BIM technology brings intuitive attention to the navigation bar of the building structure, improves the integrity of water supply and drainage engineering design, and avoids the inconsistency of structural design drawings under the traditional CAD design mode. Correlation, poor correlation, negligence and problems, BIM software can detect the application scope of each equipment in the design of water supply and drainage engineering for free. For example, there is no need to check the design value of the pipe diameter in the solid model.

4.3. Advantages of the BIM software "path planning" function

The BIM software system has the function of "path planning", which can check the overall structural design of the professional and construction projects that the designer has completed. In this way, mechanical equipment, pipelines, safety passages, pre-buried indoor spaces, etc. in the research field will not endanger other professional industries. If there are differences in the detection of authoritative experts, the designer can also correct some of the differences in time according to the detection results. The advantages of BIM technology are reasonable for the connectivity and integrity of architectural engineering design, and have comprehensive advantages.

4.4. Advantages of BIM technology for verification of engineering drawings and construction plans

The general construction conditions of construction projects are complex, and the structural design is promoted according to the 3D solid model of the BIM app, so that the construction project has the ability to reasonably adapt to the unique construction conditions, and can better adapt to the construction environment and construction specifications of the construction project. This provides reasonable and specific guidance for website construction. Using BIM technology to verify the feasibility of design engineering drawings and construction schemes can effectively reduce problems and system loopholes in related schemes, as well as the allowable rate of engineering construction [14].

4.5. BIM technology application measures

An office building has a total of 5 units, a total construction area of about 20,000 square meters, a total of 17 floors, each floor is 2.9 m, the underground parking lot is 3.9 m, and the main engine room is 4.6 m. The specific performance of the building is shown in **Figure 7**. The basic content of the water supply and

drainage design of this high-rise residence is the overall water supply and drainage system design and the design of fire protection facilities. Drainage piping design using BIM technology. The actual design points are shown below.

Figure 7. Architectural design categories.

4.5.1. Application in the construction of drainage equipment

The civil works used in the construction of drainage equipment and the design of pre-buried pipelines in construction projects include cross-type projects. Using BIM technology to design pipeline waste disposal sites can effectively prevent design changes that may occur in the middle and later stages of the project. Improve the overall construction efficiency of construction projects. Use BIM technology to create a three-dimensional model of construction engineering, and use the solid model as a carrier to design the embedded parts of drainage equipment and pipelines. When the design is changed, the designer should update the statistical data of the three-dimensional model at the same time, adjust the embedded parts of the pipeline according to the new solid model information, adjust the coordination of the pipeline network project, and increase the efficiency of the construction water supply and drainage project.

4.5.2. Applications in the design of high-rise buildings

High-rise buildings used in the design of pipeline-intensive places not only have water supply pipelines, but also natural gas pipelines, power transmission lines, etc., and various pipelines have large flow. The pipeline workshop cooperates well with each other, and the project adopt BIM technology for each specialty [15]. In addition, the designer will use BIM technology to fully predict and analyze the possible influencing factors of the pipeline network project, formulate corresponding risk prevention plans, select pipelines suitable for raw materials, and ensure that the design plan is very scientific and standardized.

The specific application formula is as follows:

Independent foundation (the boundary between the concrete independent foundation and the column on the foundation surface).

1) Rectangular foundation:

$$v = \mathrm{L} \times \mathrm{W} \times \mathrm{H} \tag{4}$$

2) Ladder-shaped foundation:

$$v = \Sigma \text{ each step (length} \times \text{width} \times \text{height)} \tag{5}$$

3) Truncated square cone foundation:

$$v = V_1 + v_2 = \frac{1}{6} h_1 \times [A \times B + (A + a)(B + b) + a \times b] + A \times B \times h_2 \tag{6}$$

Among them, V_1—the volume of the upper prism of the foundation, V_2—the volume of the cuboid below the foundation, h_1—the height of the prism, A, B—the length and width of the bottom of the prism, ab—the length and width of the top side of the prism, h_2—the height of the cuboid below the base.

4.5.3. Application in the design of the precinct's master plan

Application in the overall planning and design of the jurisdiction Due to the large number of superimposed layers of high-rise residential buildings, the water supply pressure of water supply equipment is required to be high. running quality. Project designers use BIM technology in the design process to predict, analyze and deal with the problems that may arise during the implementation of the plan under the premise of ensuring the feasibility of the design scheme of the management area to prevent construction problems.

4.5.4. Application in fire hydrant design

Fire hydrant is an indispensable part of water supply equipment in construction projects. The effectiveness of fire hydrant design is directly related to the overall fire safety level of the construction project, which is of great significance to the protection of residents' lives [16]. When designing fire hydrants, various factors such as the number of building construction layers, relative height, and plane design should be fully considered, and the monitoring and management functions of BIM technology should be used to simulate different fire hydrant mechanical equipment among the three. 3D models and associated mechanical equipment. Install and use. When a sudden disaster occurs in a high-rise residential building, the fire hydrant machinery and equipment can be fully and effectively utilized. Designers should also strictly implement the requirements and standards for the setting of fire-fighting equipment in construction projects, and strictly implement the design procedures and procedures for related facilities and equipment to ensure the rationality of fire hydrant design.

4.5.5. Application in production line intervention trials

The production line intervention test adopts BIM technology, and REVIT MEP is the key to the rational layout of the intervention test for each production line [17]. The difficulty factor of BIM application software is relatively low, and designers can also input the parameters of power supply and sewage pipelines in the main corresponding control modules. After entering the main parameters, the program flow automatically gradually folds the check. It indicates that there are common fault connection points of pipelines in the current design scheme. According to the conclusion of the path planning, let the designer determine the location of the change

of the layout of the water supply and drainage pipeline to provide support for the construction of the project.

4.6. Comprehensive application methods and advantages of integrating biomechanics and biomimicry with BIM technology

4.6.1. Integrated application methods in the design phase

During the design phase, combining the principles of biomechanics and biomimicry with BIM technology can significantly enhance the innovation and efficiency of architectural design. By creating detailed three-dimensional models using BIM software and drawing inspiration from the optimized designs of biological structures in nature, such as the hexagonal structures of honeycombs or the branching patterns of trees, these designs not only improve the stability and durability of buildings but also effectively reduce the amount of materials used.

4.6.2. Characteristics and advantages of biomechanical simulation in BIM design

The high-precision three-dimensional models and rich data integration capabilities provided by BIM technology allow biomechanical simulations to accurately reflect the stress states and energy consumption performance of building structures during actual use. Biomechanical simulations can model eco-friendly design solutions such as natural ventilation and light distribution, helping designers optimize the building's environmental adaptability and energy utilization efficiency. By simulating the natural shading effects of plant leaves, designers can implement intelligent shading systems within the BIM model, reducing the building's reliance on artificial lighting and air conditioning systems, and thereby lowering overall energy consumption.

5. Green energy-saving design optimization based on BIM technology

5.1. Improve the application level of BIM technology

BIM technology application level

The application of BIM technology in energy-saving design can comprehensively interpret building energy consumption and complete new green energy-saving buildings with low energy consumption and in line with my country's regulations. At present, most of the energy-saving analysis software is imported from abroad. For example, the energy saving analysis software Ecotect Analysis). The computer simulation analysis software developed by Autodesk analyzes the thermal environment of engineering buildings, the natural environment of lighting fixtures, the role of environmental noise and economic environment, cost analysis reports, meteorological data and other key building environments. Analysis criteria database is not localized. The specific construction steps are shown in **Figure 8** [18]. In order to widely apply BIM technology in energy-saving design, it is necessary to gradually improve and optimize the application level of relevant analysis tools and BIM technology in energy-saving ana lysis, and digest and absorb the advantages of

foreign software and technology. The theoretical awareness of basic operation is more conducive to the promotion of green energy-saving buildings and energy-saving engineering buildings.

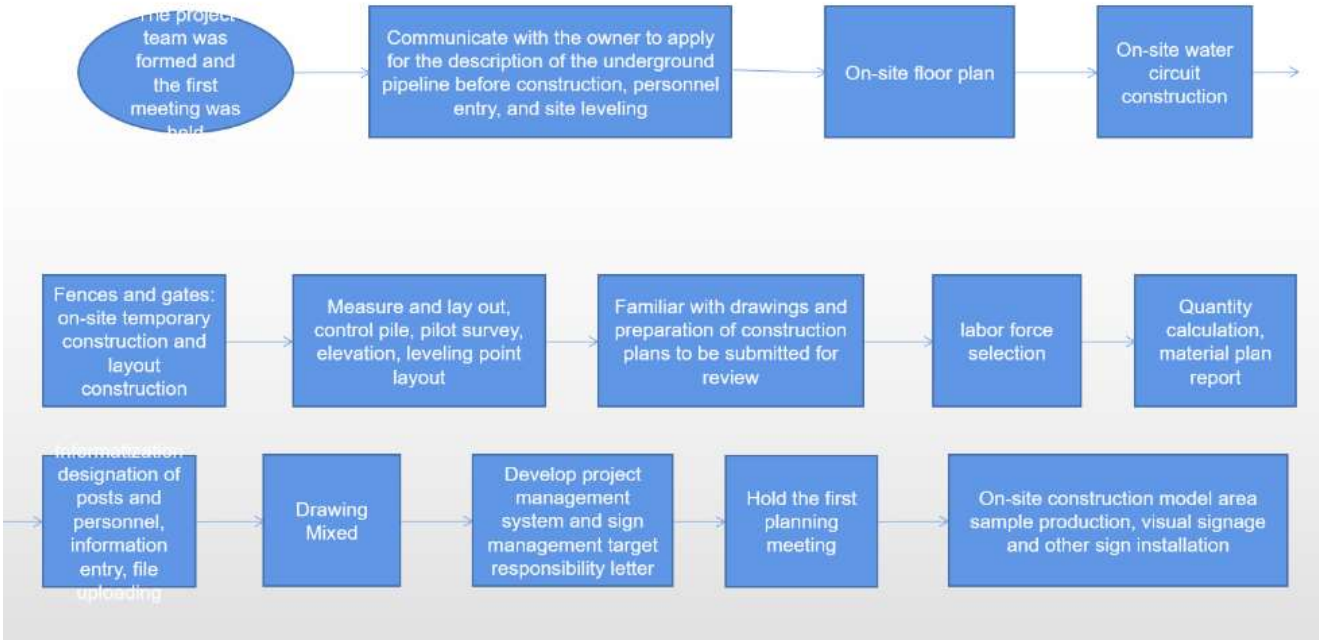

Figure 8. Construction steps of high-rise residential buildings.

5.2. Strengthen the training of BIM technical talents

BIM technology is the most worrying issue in energy-saving design at this stage. my country's BIM technology is still in the development stage, the application cycle is short, and there is a lack of advanced BIM technology application talents. Not only should it be guided by the talent strategy including the allocation mechanism and the current policy incentive mechanism, etc., but also keep in mind that the on-site employees "part-time solve errand services" and will not cultivate talents. New technology, but there will also be counter-forces.

5.3. clearly put forward the development trend

BIM shows various advantages in practical applications, but there are also limitations such as inconsistent implementation standards, low collaborative management capabilities, and imperfect industrial chain systems [19] .In order to promote the application and development of this technology in the foreign construction industry, government agencies and the construction industry should understand the application advantages of BIM technology, promote the application of BIM technology in industrial development planning, and use BIM technology to build the cooperation capacity of various departments. At the same time, the development of BIM technology has been improved, and BIM software tools and BIM mobile software have been completed.

5.4. Comprehensive green energy-efficient design based on biology and BIM technology

In green energy-efficient design, combining biological principles with BIM technology can achieve more efficient and sustainable building solutions. Biology provides natural inspirations for architectural design, such as biomimetic structures and ecosystem concepts, helping to optimize building energy consumption and environmental adaptability. Through BIM technology, designers can integrate these biological principles into architectural models to perform accurate energy consumption simulations and performance analyses. BIM's parametric design features allow designers to quickly adjust and optimize biomimetic design elements, ensuring that buildings meet functional needs while achieving optimal energy efficiency and environmental friendliness. Therefore, the integration of biology and BIM technology not only enhances the innovativeness of architectural design but also significantly improves the overall energy-saving performance of buildings. The integrated green energy efficient design based on biology and BIM technology is shown in **Table 4**.

Table 4. Comprehensive green energy-efficient design based on biology and BIM technology.

Design Idea	Typical Element Integration Method	Typical Application Example
Biomimetic Structure Optimization	Borrowing structures from nature, such as the hexagonal structure of honeycombs	Use honeycomb structures to optimize building frameworks, enhancing stability and energy efficiency
Natural Lighting and Ventilation Design	Simulating photosynthesis and airflow patterns of plant leaves	Design windows that mimic tree leaf shapes to achieve efficient natural lighting and ventilation
Ecological Water Cycle System	Rainwater collection and utilization mechanisms in biomimicry	Integrate rainwater harvesting systems into buildings to reduce water usage and improve water resource utilization
Biomimetic Insulation Material Application	Applying natural insulation principles from biomimicry, such as the insulating layers of Antarctic animals	Use biomimetic insulation materials to build exterior walls, enhancing building insulation performance
Renewable Energy Integration	Simulating energy conversion in nature, such as photovoltaic leaves	Integrate photovoltaic panels into building exteriors to utilize solar energy for power supply

6. Concluding remarks

The water supply and drainage system are the key equipment to ensure the daily life of engineering buildings. The water supply and drainage system software have a certain connection with the construction industry. When planning the traditional water supply and drainage system, due to technical limitations, there are many problems in the planning and design, such as incoordination, pipeline contradiction, and unscientific and reasonable layout. The application of BIM technology breaks the limitations of traditional design scheme technology, improves the docking ability of various design processes of engineering buildings, and effectively improves the design quality of drainage equipment. An overview of residential buildings is shown in **Table 5**.

Table 5. Overview of high-rise residential construction.

serial number	file name	test result	serial number	file name	test result
1	Engineering construction project approval, approval or filing documents	have	10	Examination Opinion on Seismic Fortification of Exceeded High-rise Building Projects	/
2	Energy saving review opinions or registration filing documents for fixed asset investment projects	have	11	Lightning Protection Device Design Review Opinion	have
3	Construction land approval or land use certificate	have	12	Construction drawing design document review certificate	have
4	Construction land planning permit	have	13	Bid-winning notice for survey, design, construction, supervision and testing	/
5	Construction Project Planning Permit	have	14	Contracts for survey, design, construction, supervision, and testing (including construction majors and labor subcontracting)	have
6	Firefighting facility document review opinion or filing certificate	/	15	Quality and safety supervision registration form	have
7	Environmental Impact Statement or Environmental Report Form or Environmental	have	16	Construction Work Permit or Commencement Report	have
8	Civil air defense engineering approval documents for civil construction projects	/	17	Other construction procedural documents required by laws, regulations and seals	/
9	Impact Registration Form	/			

The comprehensive green energy-efficient design, based on biology and BIM technology, effectively optimizes numerous flaws in traditional architectural planning and design by integrating biological principles with BIM technology. This integration significantly enhances the energy efficiency and environmental adaptability of buildings while maximizing the conservation of our network resources [20]. Biology provides valuable insights from the natural world for efficient energy management and structural optimization in architectural design, such as biomimetic structures and ecosystem design concepts, enabling more scientific and rational adjustments to both the internal and external structures of buildings. During the comprehensive design process, BIM technology is utilized to create precise three-dimensional models that simulate and analyze the impacts of natural phenomena and special conditions on buildings, thereby generating the most ideal architectural solutions [21,22]. Biology-based design elements are thoroughly validated and refined on the BIM platform to ensure their superior performance under various environmental conditions.

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