Review Article

Architectural Drawing and Design Modeling Strategies in Building Systems

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ABSTRACT

The concept of building information modeling (BIM) was developed in the mid-1970s and became known as building description systems. Today, this process has become the focus of attention as a broad field of knowledge in the construction industry and has been implemented to respond to the need for integration, improved communication and information in some projects. This concept refers to a set of strategies, processes, and technologies that create a method for managing project life cycle information. This technology is an advanced process related to planning, design, construction, operation, and management using BIM by new and old devices and programs and potentials. In other words, this technology is defined as a fully related set of all construction processes including: production, communication and analysis of construction models. According to this standard, by implementing this concept, all project life cycle information is stored in a common data environment. In other words, BIM is an intelligent process based on 3D models that provides architectural, engineering, and construction professionals with insights and tools for planning, designing, constructing, and managing buildings. New building technologies are fundamentally changing the way construction and project management are conducted. These technologies enable the construction of higher quality structures at lower costs by increasing the speed, accuracy, and efficiency of construction processes. On the other hand, these technologies also help improve sustainability and reduce the environmental impact of construction projects. In the near future, these technologies are expected to become a standard in the construction industry and have a significant impact on traditional methods. Therefore, familiarity with these technologies and their use can help companies and professionals in this field to be more successful in future competitions.

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Introduction

BIM is recognized as one of the most advanced digital technologies in the construction and architecture industry [1]. By providing a comprehensive platform for managing project data and information, this technology has enabled coordination between different teams and increased project accuracy and efficiency. In recent years, the integration of BIM with artificial intelligence (AI) and machine learning (ML) technologies has brought this technology to a higher level. In this article, we examine the role of ML in improving BIM efficiency [2], AI applications, and analyze the three main stages of BIM and AI: past, present, and future. BIM is one of the most advanced technologies in the construction industry that has significantly transformed the design, construction, and renovation processes of buildings in recent decades. This technology has become one of the key tools in building renovation due to its ability to provide accurate and comprehensive data. Construction technology, as one of the important areas of the construction industry, is used in various construction and structural projects [3]. Some of the applications of this technology include:

Building design with the help of 3D software and advanced structural modeling systems.

Using modern and modern construction materials and equipment such as fiber concrete, seamless steel, ceiling foam, smart windows, etc.

Using modular and prefabricated construction methods that reduce construction time and costs, increase implementation speed and improve construction quality.

Using sustainable and smart energy systems that reduce energy consumption, improve indoor air quality and reduce energy consumption costs [4].

Using construction management systems that improve the quality and efficiency of construction processes, reduce errors and additional costs, and improve project control.

Using smart building methods that increase the comfort and security of residents, improve the quality of life, and reduce maintenance costs.

Improve the durability and resistance of structures to earthquakes and environmental problems.

Improve the level of safety and health in the workplace and reduce construction accidents.

Improve the quality of life of people by improving the quality of housing and creating better urban spaces [5].

As construction technology continues to advance, new capabilities will be added to this list.

What is BIM?

BIM is a digital process that integrates information related to the design, construction and management of a building into a 3D model. This technology includes not only the geometry of the building, but also information such as materials, costs, schedule and performance. In building renovation [6], BIM allows for a detailed analysis of the current state of the building and optimal planning for the required changes. Building renovation is often challenging due to complexities and uncertainties such as unexpected structural conditions, design difficulties, and the need for coordination between different parts of the project (Figure 1). Using BIM in this process can:

Accuracy in assessing the existing condition

With laser scanning and existing data, it provides an accurate picture of the building.

Cost reduction

Identify problems before work starts and optimize processes.

Improve team coordination

Facilitate communication between architects, engineers and contractors.

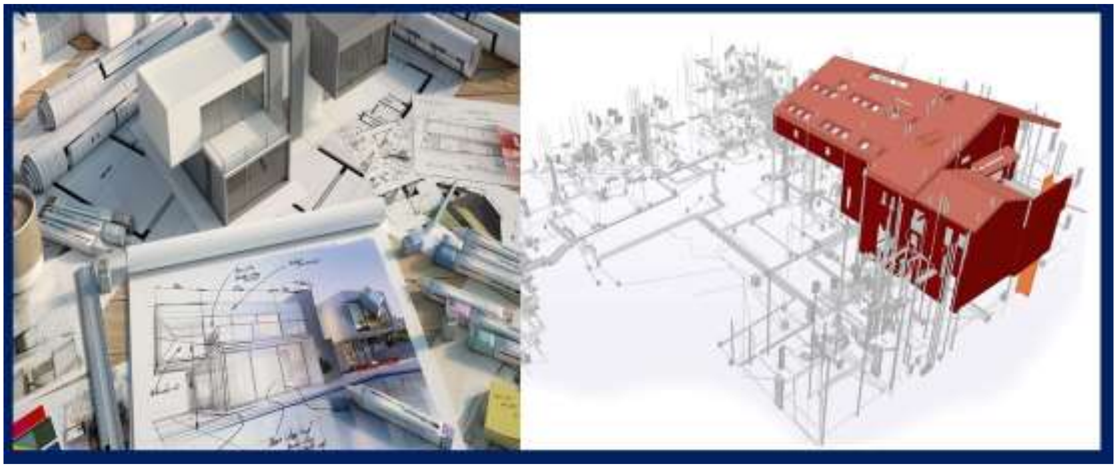

Figure 1. Architectural drawing and design modeling strategies in building systems

Better schedule management

Create accurate schedules and anticipate challenges [7].

Some of the main areas of BIM application and the role of AI in improving them

Some of the main areas for BIM application, each of which can be significantly improved by using AI, are as follows:

Design and design evaluation tools

Design tools developed on the BIM platform can include various software for 3D design. These tools are typically used to optimize the design and improve the quality of the project. With the use of AI, these tools can reach a higher level of automation. For example, automating the design and evaluation of various options. AI models can automatically generate hundreds of different design options and select the best option based on criteria such as strength, cost, and aesthetics [8].

BIM-to-field tools

This category includes tools that transfer information from BIM models directly to the construction site. This information transfer can be done through 3D views, interactive maps, or even augmented reality (AR) tools. In this area, AI can be used to quickly process data and create understandable models for workers and contractors.

Accurate display of information on the construction site

Using AI techniques, especially image processing, BIM models can be automatically converted into data needed on the construction site and displayed to workers through smart displays or augmented reality glasses (AR glasses).

Robotic tools for construction operations

This category includes robots that can automatically perform various construction operations. For example, welding robots, concrete pouring robots, or wall-laying robots.

Field-to-BIM tools for site data collection and analysis

This category includes tools that transfer information collected from the construction site to BIM models. These tools can use various technologies such as laser scans, drones, and smart sensors to create more accurate models.

Project performance monitoring and quality control

AI tools can compare information received from the site with BIM models and report any

2024, Volume 5, Issue 4

discrepancies to the project management team [9].

For example, in a construction project in Shanghai, drones equipped with 360-degree cameras were used to monitor the progress of the project. This system was able to accurately assess site performance and automatically identify any delays in project implementation. As a result, project managers were able to save more than 10% in monitoring costs by using this system.

Application of ML in BIM

ML is recognized as one of the key and important areas in improving BIM performance. The use of ML algorithms in various processes of the building life cycle allows for improved data analysis, prediction of system behaviors, and resource optimization. The following are some of the most important applications of ML in BIM:

Data classification and management

ML models are used as an effective tool for classifying and managing BIM data. Given the large volume and complexity of data generated in BIM processes, using traditional methods to organize this data is inefficient. This is where ML algorithms can help organize, categorize, and identify patterns in data [9].

For example, classification algorithms such as support vector machine (SVM) and Random Forest can identify data related to different building components and categorize them based on type, function, and geographic location. This process not only helps reduce errors in the data, but also allows for more efficient use of existing information. In a complex construction project, classification algorithms were used to identify incomplete and inconsistent data in 3D designs. These models were able to accurately identify incorrect sections and help the engineering team quickly fix problems before the project was implemented. The result was a 15 percent reduction in additional costs and a 10 percent improvement in project execution accuracy.

Predicting structural behavior

Another important application of ML in BIM is predicting the structural behavior of buildings under different conditions. Using neural network models and other prediction algorithms, it is possible to simulate the response of a structure to different loads such as earthquakes, wind, or temperature changes. These predictions allow engineers to take preventive measures and provide designs that are more resistant to different natural conditions [10].

For example, in a bridge construction project, ML models were used to predict the amount of deflection and vibration of the structure under high wind conditions. The results of these predictions helped engineers improve the design and increase the structural stability. The use of these models led to a 20% reduction in risks caused by weather conditions and a 25% increase in the useful life of the structure.

Optimization of construction processes

ML models can be used to optimize construction processes and resource allocation. In complex construction projects, optimal resource scheduling and allocation is of great importance. Using ML algorithms, the best planning for the use of resources such as raw materials, manpower, and machinery can be done. Reinforcement learning algorithms can suggest the most optimal routes and schedules for projects by learning from past data and simulating different scenarios [11].

For example, in a large-scale construction project, the use of reinforcement learning algorithms for more accurate planning and resource allocation led to an 18% reduction in operating costs. These algorithms helped the management team reduce wasted time and increase the productivity of the whole project.

Collision detection and interference prevention

Another application of ML in BIM is the detection of potential conflicts between different building components such as plumbing, electrical wiring, and mechanical structures. ML can identify these conflicts more

2024, Volume 5, Issue 4

effectively and provide appropriate solutions to resolve them, which reduces the delay time and costs of subsequent modifications.

For example, in a large hospital construction project, ML models were used to identify conflicts between electrical and air conditioning systems. These models were able to detect more than 95% of conflicts that were not detected by traditional methods and prevent remediation costs.

A look at the past, present, and future of BIM and AI

Three main stages have been defined to examine the state of BIM and AI. Known past, uncertain present, and optimistic future. We will examine these three stages as follow:

Known past

At this stage, many BIM and AI techniques and tools were presented as ideas that were not possible to implement due to technical limitations. Early techniques for automated design, such as rule-based systems, were proposed in the 1980s, but these systems were not used in industrial environments due to lack of processing power and the absence of unified information models. Early ideas for building code control and automated code checking were also proposed, but the lack of unified standards and problems with natural language understanding made these systems ineffective [12]. For example, the first AI -based systems such as HI-RISE were developed in the 1980s for the design of high-rise structures, but due to processing limitations, they remained only in laboratory environments.

Uncertain present

Today, many automated design and code compliance systems have been launched on the market, but they still need to standardize models and increase the accuracy of analyses. Software such as Solibri Model Checker and BIM Assure are among the commercial tools available that can automatically check some building codes. AI can emerge as an efficient solution here. As it uses natural language processing (NLP) and semantic analysis algorithms to transform building codes and regulations into machine-process able forms. However, the main challenge remains the adaptation of models and the need for accurate and integrated data.

Optimistic future

The BIM future will move towards a smarter and more accurate environment by integrating more advanced automated systems and creating Digital Twins. The use of Digital Twin and AR will allow for the real-time digital version of physical assets to be displayed in the real environment (Figure 2). Using AR, users can see changes and performance of physical systems in real time and interact with the digital model to help optimize operations and detect problems before they occur. This combination increases the accuracy and speed of project management and execution. Future systems are expected to have the ability to automatically analyze all building codes, complex designs, and manage the entire project life cycle [13].

Challenges of using BIM in building renovation

High initial cost

BIM implementation requires significant investment in software, equipment, and staff training.

Complexity in learning

To use BIM effectively, teams must have received the necessary training, which may be time-consuming.

Resistance to change

Some people may resist adopting BIM due to their habit of traditional methods.

2024, Volume 5, Issue 4

Figure 2: Application of ML in BIM

Need for accurate data

The quality of the BIM model depends on the initial data. Any flaws in the collected data can lead to serious errors [14].

The role of BIM in sustainability and energy saving in building renovation

The use of BIM in building renovation can have significant positive effects on sustainability and reducing energy consumption. Some of these effects include:

Energy performance simulation

The ability to analyze and optimize energy consumption before implementation.

Sustainable material selection

Providing data for selecting materials with a lower environmental impact.

Optimal design of ventilation and lighting systems

Using simulation and real data.

Successful examples of using BIM in building renovation

Renovation of historic buildings

In historic building renovation projects, BIM has been used to document existing conditions and plan changes in detail.

Energy optimization

In green projects, BIM has been used to simulate energy performance and reduce natural resource consumption [15].

Complex project management

In projects that require coordination between multiple teams, BIM has served as a key tool for project management.

Smart architectural design

Smart architectural design is an innovative approach in the architecture industry that uses advanced technologies such as AI, internet of things (IoT), and BIM to create efficient, beautiful, and sustainable spaces. This type of design focuses not only on the appearance of buildings, but also pays special attention to their functional and environmental needs. Smart design uses real-world data and advanced simulations to optimize every aspect of a project, from structure and space utilization to energy consumption and resource management. The main goal of this approach is to create buildings that can automatically adapt to their surroundings and users' needs, while minimizing their environmental impact [16].

How does smart architectural design work?

The performance of smart architectural design is based on the use of advanced tools and software that enable accurate analysis of information and implementation of ideas. For example, BIM technology allows architects to manage all aspects of a project from design to execution in a comprehensive 3D model. Furthermore, using the IoT, various building components such as lighting, air conditioning and security systems can be connected to each other and provide the most optimal performance with automatic adjustments. AI also helps architects analyze data, predict needs, and suggest creative solutions. The end result is buildings that are not only beautiful and modern, but also create a unique experience by intelligently using energy, reducing costs, and increasing user comfort [17].

The role of virtual reality (VR) and AR in the evolution of architectural design

As revolutionary tools, VR and AR have brought architectural design to a new level of creativity and efficiency. Using VR, architects and clients can immerse themselves in a three-dimensional environment and fully experience the designed space before construction begins. This technology allows for the identification and correction of potential defects in the early stages of the project, which can significantly reduce project costs and implementation time. On the other hand, AR allows architects to integrate digital designs into the real world and see their impact live in different environments. These tools have not only streamlined the design process, but also facilitated communication between architects, clients, and contractors, leading to more creative, efficient, and high-quality buildings [18].

BI) (a tool for the future of architecture)

BIM is one of the most advanced design and management tools in the architecture and construction industry that has revolutionized the way projects are planned and executed. By creating accurate 3D models, this technology provides comprehensive information on all building components, from initial design to post-construction maintenance and management. BIM allows architects, engineers, and contractors to collaborate in a shared environment, make smarter decisions, and minimize potential errors. In addition, using BIM saves time and money on projects and helps improve the buildings' efficiency and sustainability. This tool will guide the future of architecture towards intelligent designs, optimized processes, and higher quality buildings [19].

How AI is turning architectural design ideas into reality?

AI has revolutionized the design and implementation process in the architectural world. Using ML algorithms and sophisticated data analysis, this technology allows architects to create their designs more intelligently and efficiently. AI can use environmental data, user needs, and project requirements to come up with ideas that are not only creative, but also optimal and practical. For example, AI-based design software can analyze geographical conditions, lighting, ventilation, and energy consumption to suggest the best layout and construction materials. This approach not only increases design quality, but also minimizes the cost and time required to modify initial designs. On the other hand, AI can play a key role in the process of converting initial designs into workable models. Via advanced technologies such as automated 3D modeling, architects can turn their ideas into accurate and realistic models at an unprecedented speed. These models allow architects and contractors to review project details and anticipate potential problems before construction begins. AI also enables accurate simulations to accurately assess the impact of the design on the environment and users. The result of this collaboration between AI and human creativity is buildings that are simultaneously beautiful, efficient and sustainable, meeting the needs of today and tomorrow [19].

Sustainable technologies in architectural design (a step towards green buildings)

In this era when climate change and environmental crises have become one of the most important global challenges, sustainable technologies in architectural design play a vital role in moving towards green buildings. These technologies help architects design buildings with the least impact on the environment by reducing energy consumption, optimizing the use of natural resources, and reducing environmental impacts. From smart energy management systems and solar panels to the use of recycled materials and designs to reduce water waste, these innovations create efficient and environmentally friendly buildings. Green buildings are not only environmentally sustainable, but also ensure an improved quality of life for users and are considered as a model for future architecture.

The role of 3D printing in construction and design of modern architecture

As one of the most advanced construction technologies, 3D printing has been able to revolutionize the design and implementation of modern architectural projects. This technology enables the accurate and rapid production of complex building components and has eliminated traditional limitations in design and construction [20]. Using 3D printing, architects can produce conceptual models, detailed mock-ups, and even actual building components with high precision and save time and money. In addition, this technology helps to optimize the use of materials and reduce construction waste, which ultimately leads to more sustainable projects. 3D printing has not only expanded the creativity of architects, but also paved the way for innovative designs and the construction of buildings with forms that were impossible in the past [21].

How has technology simplified the communication between architects and contractors?

Technology has made the communication process between architects and contractors significantly simpler and more efficient by introducing digital tools and advanced software. Tools such as BIM, online project management systems, and mobile applications make it possible for all project information and changes to be available to all team members simultaneously and up-to-date. In the field of construction contract management, these technologies help contractors and architects to have more accurate coordination and prevent errors due to lack of coordination. Likewise, using cloud platforms, architects and contractors can easily share documents, drawings and changes and receive immediate feedback. The result of this coordination is improved decision-making, reduced costs and project implementation time, and ultimately better construction quality [22].

Smart buildings (architectural design for digital living)

Smart buildings refer to buildings that use modern technologies to improve efficiency, comfort and security. In the architectural design of these buildings, advanced systems such as the IoT, AI, and intelligent energy management systems are seamlessly integrated into the structure and design of spaces. Using these technologies, architects are able to create spaces that automatically respond to environmental changes. For example, adjusting lighting and temperature based on the needs of people in the space or controlling building security through smart cameras and motion sensors. This type of design not only helps improve the quality of life, but also optimally reduces energy consumption and uses resources. In these buildings, every detail, from interior design to security and energy systems, is intelligently connected to provide a comfortable and efficient experience for residents. From automatic doors and smart sound systems to intelligent energy management, all these features make smart buildings the ideal space for digital living. In addition, these buildings can automatically respond to environmental changes such as weather conditions or the number of people in the space, using new technologies, and continuously identify and meet the needs of residents. Ultimately, architectural design for digital living means creating spaces that not only meet human needs, but also contribute to improving the quality of life and environmental sustainability [23].

Discussion

BIM has successfully addressed the challenges associated with the increasing complexity of building projects and has revolutionized the planning and construction process. BIM brings together all the data from different disciplines into a single, digital system, enabling virtual construction before actual construction begins. This approach not only increases planning accuracy, but also reduces the risks associated with traditional construction methods. BIM goes beyond traditional 2D and 3D drawings and connects them to a rich database that includes detailed information such as element descriptions, material quantities, and associated costs. This comprehensive database fosters seamless collaboration between teams from different disciplines, virtually eliminating communication gaps and minimizing the need for costly rework. As an integration platform, BIM guides all stakeholders, including architects, engineers, contractors, and clients, on the same path. Our BIM services include:

Integrated BIM-based design

We provide BIM-based design services across all disciplines including architecture, structure, mechanical, electrical, and plumbing (MEP). This integrated approach ensures that all aspects of the design work together harmoniously and consistently.

3D modeling and visualization

Advanced 3D modeling and visualization services allow stakeholders to virtually visualize the project. This helps identify potential issues early in the design process and leads to informed decision-making [24].

VR

We use VR technology to allow clients to walk through and tour the project space before it is built. This service not only enhances a quick and easy visual understanding of the environment, but also helps improve designs based on real-time feedback from moving around in the virtual space.

Coordination and conflict detection

BIM services include careful coordination of disciplines and conflict detection, to ensure that all building systems work together in harmony. This process helps identify and resolve conflicts between different systems at an early stage, preventing costly changes during construction.

Virtual planning and management

We use BIM for comprehensive project planning and management, adding time dimension and preparing a four-dimensional (4D) model, and adding costs and preparing a five-dimensional (5D) model. This helps ensure that projects are completed on time and within budget.

Construction logistics optimization

BIM expertise helps optimize construction logistics, increase efficiency, and reduce waste [25].

The impact of new technologies on architectural drafting and mapping

With the advancement of technology, new tools and software have entered the world of architecture that have dramatically changed the process of architectural drafting and mapping. Technologies such as VR and AR now allow architects to view their designs in real environments and make necessary changes quickly. These technologies not only help architects better communicate with their clients, but also make them understand their needs more accurately and implement plans and designs more optimally [26].

The role of technical drawing in achieving architectural sustainability

Technical drawing and architectural drafting are not only essential for the design and construction of buildings, but also play a fundamental role in the field of architectural sustainability. Using accurate maps, architects will be able to optimize energy consumption. The sustainable materials and design green spaces are used properly. These processes help reduce the negative impact on the environment and lead to buildings with better performance and lower energy consumption.

Key challenges in architectural drafting

Despite the high importance of architectural drafting and drawing, architects face several challenges in this field. One of the main challenges is the frequent changes in client requirements, which may lead to constant revisions to the drawings. Likewise, the lack of coordination between different implementation teams can cause problems in the construction process. To deal with these challenges, architects need to strengthen their communication and management skills and use project management software effectively [27].

The future of architectural drafting and drafting

The future of architectural drafting and drafting will be heavily influenced by technological advances. With the advent of new technologies such as AI and ML, the design and drafting process will be automated and more efficient. These technologies will help architects reduce design time and costs, while significantly increasing the final quality of projects. In addition, the use of technologies such as BIM and 3D printing will also make the design and construction process faster and more accurate. It seems that in the future, architectural drafting and drafting will be completely digitalized and automated, and architects will focus more on innovation and creativity. Architectural drafting is a vital skill for the architect. This skill is the foundation of the design and construction process of buildings. Accurate drawings help architects to clearly communicate their ideas to the executive team and clients. Architects can also design complex structures correctly and prevent problems during the construction stages. Skills in technical drawing and architectural drawing also help reduce project time and costs and deliver higher quality projects. Without these skills, the design and construction process would be significantly more complicated and costly [28].

Technical drawing is the foundation of every design project

Technical drawing in architecture is an essential part of every design project. This stage of the design process helps architects to accurately and understandably portray their ideas to the executive team and clients. The technical drawings prepared at this stage serve as a roadmap for the next stages of the project and prevent possible problems during the construction stages. Without accurate technical drawings, architectural projects may suffer from problems with structure, safety, or coordination between different teams. Accordingly, technical drawings not only help with design accuracy, but also affect project time and cost management. Architectural drafting is the process of converting initial design ideas into detailed construction plans. In this stage, architects must accurately draw the technical and structural details of each part of the project so that the construction team can correctly implement them [29]. Architectural drawings not only act as a construction guide, but also allow architects to convey their ideas in a clear and understandable way to all project parties, including engineers and contractors. Learning the stages of technical drawing in architecture is of great importance. Because this skill is a basic skill for any professional architect. Various stages of technical drawing, from preliminary design to preparation of construction plans, allow architects to implement their designs accurately and effectively. To start learning this essential skill, it is crucial to have proper and step-by-step training. Our “plan Design 0 to 100” course can be a comprehensive and complete guide for you to achieve sufficient mastery of this skill by focusing on the different stages of technical drawing. Architectural drawing plays a key role in the management of architectural projects. Accurate and technical drawings help architects to control the implementation stages of the project more effectively and establish better coordination between different teams. Using up-to-date and accurate drawings, architects can better plan for scheduling and resource allocation. This process, besides reducing implementation errors, helps to increase quality and reduce costs during the project. Therefore, skills in technical drawing and architectural drawing are of great importance and can have many positive effects in the management of architectural projects. Although you can learn technical drawing and architectural drafting by self-study, specialized training helps you learn these skills faster and more accurately. By learning the right principles, you can better understand the basics and advanced topics. These skills will help you in designing plans, managing projects, and communicating effectively with executive teams [30]. Formal training allows you to learn the design stages from drawing basic plans to executive details in a fundamental and practical way. This process will not only strengthen your skills, but also help you complete your projects with higher quality and in a shorter time. If you also want to learn plan design from zero to one hundred professionally, the 0 to 100 plan design training course is a great opportunity for you. By completing this course, you can learn plan design comprehensively and professionally and become a professional architect. For architects who plan to use software such as Royet Architecture, mastering technical drawing and mapping is of particular importance. Because software such as Royet is designed based on technical drawing, and without a proper understanding of these concepts, you may encounter problems in modeling, communication between teams, and project management. Therefore, learning technical drawing plays a key role not only in initial design, but also in working with software such as Royet. Specialized training in technical drawing will help you to be more successful in this field and use the advanced features of this software effectively [31].

Conclusion

BIM is the process of developing and producing a computer model to simulate planning, design, construction, and operations. The result of BIM is a data-rich, object-oriented, intelligent, and parametric digital model that provides visual and data output to meet the diverse needs of specialized users. In this way, the user can extract and process the views and data they need from the BIM model and thus obtain information that is relevant for decision-making and the improvement of the presentation and review of facilities. A BIM model specifies the geometry of the building, spatial relationships, geographic information, the quantity and characteristics of the building's execution, cost estimates, lists of required materials, and project schedules. It can also show the entire life cycle of the building, as a result, the quantities and characteristics of materials can be quickly and easily extracted from the BIM model, and the scope and different parts of the work can be easily separated and redefined. Systems and arrangements can be displayed at scale in relation to the entire building or a group of building facilities. Similarly, construction documents such as drawings, prepared details, proposed processes and other specifications can be easily linked to each other. Making a building model and maintaining information related to the building, structure, and its facilities can greatly increase the quality of service provision in each of the following stages and, conversely, reduce the cost and time required for their implementation. Maintaining information related to architecture, structure, and facilities. Managing possible changes in the building, structure, or facility. Managing the costs of the building's life cycle, building insulation, and knowing its quality. Managing fire and fire extinguishing equipment and predicting building maintenance and repair costs. Managing the supplies and equipment used in building construction and facilities. Scheduling and controlling the stages of building construction and the logistics of tools and equipment used in construction. Building facilities management and building maintenance and repair management and building warranty. Managing building demolition and renovation and building improvement and restoration.

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