ADVANTAGES OF BIM TECHNOLOGY APPLICATION: A CASE STUDY OF A CONSTRUCTION COMPANY

By

Miss Zijing LIU

A Thesis Submitted in Partial Fulfillment of the Requirements
for Master of Engineering ENGINEERING MANAGEMENT
Department of INDUSTRIAL ENGINEERING AND MANAGEMENT
Silpakorn University
Academic Year 2023

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MissZijing LIU

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรวิศวกรรมศาสตรมหาบัณฑิต
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มหาวิทยาลัยศิลปากร
ปีการศึกษา 2566

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By	Miss Zijing LIU
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Advisor	Noppakun Sangkhiew, Ph.D.

Faculty of Engineering and Industrial Technology, Silpakorn University in Partial Fulfillment of the Requirements for the Master of Engineering

-- Dean of Faculty of Engineering and Industrial Technology
(Assistant Professor Arunsri Leejeerajumnian, Ph.D.)

Approved by

-- Chair person
(Associate Professor Choosak Pornsing, Ph.D.)

-- Advisor
(Noppakun Sangkhiew, Ph.D.)

-- External Examiner
(Thanongsak Thepsonthi, Ph.D.)

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Engineering construction is the first step in architectural design, so every update in architectural design technology is a revolution. The first revolution was with the development and promotion of CAD technology, as designers shifted from manual drawing to electronic drawing. However, two-dimensional drawings and three-dimensional models cannot directly reflect various information of buildings, nor can they be directly used for on-site construction. The construction industry urgently needs a higher level of new technology that can improve production efficiency, save costs, shorten construction time, and increase corporate profits. So BIM technology emerged, truly realizing the direct application of digital technology in the engineering and construction industries, and achieving the sharing of project lifecycle data. It will become the second revolution in the construction industry and also an information revolution.

The construction industry in China is very prosperous, but the overall profits of construction enterprises are relatively low. The industrialization and informatization level of the construction industry is still relatively low, and the advantages and value of BIM have not been fully utilized in the Chinese construction industry. As one of the effective ways to improve the efficiency and profits of the engineering construction industry, BIM technology needs to be improved in its application level. In the future, traditional engineering quantity calculation will become a thing of the past. Engineers should find a more effective way to carry out construction. With the widespread application of BIM technology, various data of engineering projects have been more effectively utilized, and data exchange and sharing have become more convenient. This is an effective way to improve the efficiency of the construction industry and corporate profits. We must keep up with the development of the times, constantly learn new knowledge and technologies, and jointly promote the development of the industry.

This article will actively explore the influencing factors and application status of BIM technology, and determine whether BIM technology has application prospects and significance in China's construction industry. Through research and analysis, we can further understand the application advantages of BIM technology and help enterprises better utilize BIM technology for the benefit of enterprises.

This study will use a random sampling method to collect data through online questionnaire surveys. By collecting data and analyzing the application, influencing factors, and current situation of BIM technology in leading enterprises in China's construction industry, we can determine whether BIM technology has application prospects and significance in construction. At the same time, through research and analysis, further gain the application advantages of BIM technology, and help enterprises better utilize BIM technology for the benefit of enterprises.

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CHAPTER 1
INTRODUCTION

1.1 Motivation

According to Huajing Industrial Research Institute (2023), the industrialization and informatization level of China's construction industry is still relatively low. In 2021, the proportion of construction informatization investment to the total construction output value was about 0.13%, far lower than the average level of 1% in developed countries and 0.30% lower than the international average level （Huajing Industrial Research Institute，2023）. Another research pointed out that 20% of large and medium-sized construction projects in China have carried out informatization work; 61% of the projects are still at the application level of office word processing and simple tool software, and the overall informatization the degree is very low. As one of the effective ways to improve the efficiency and corporate profits of the engineering construction industry, informatization urgently needs to be improved (Pan and Zhao,2012).

Engineering construction is based on architectural design as the first step. In the past, the development and promotion of CAD (Computer Aided Design) technology made designers move from plane manual drawing to electronic drawing, and convert drawings into 2D data in the computer, which was the first revolution in engineering construction.

Two-dimensional drawings have great deficiencies in the use process, they cannot directly reflect various information about buildings. With the continuous development of computer considering and programming technology and the widespread use of computers, relevant designers are also whether it is possible to construct 3D models on computers to more intuitively reflect various information about buildings. As a result, 3D wireframes appeared to represent the designed buildings.Then 3D modeling and rendering software such as 3D Studio Viz and Forz appeared, which could give different colors to the surface of the building to represent different materials. Optical effects, resulting in architectural renderings. However, this 3D architectural model only considers the computer environment, design volume, shape, altitude, and external space, and cannot be directly used for on-site construction. It is directly used to guide the on-site construction drawings (Zhang,2012). The drawings contain a lot of complex professional information: the geometric dimensions of the building, construction technology, the specifications of the materials used, the wind resistance strength, the earthquake resistance, etc. Only after this information is determined, the construction budget, on-site construction and other follow-up work can be carried out smoothly.

Building Information Modeling (BIM) is different from 2D drawings and 3D wireframes in that it integrates parameter models to share and transmit relevant information of various projects throughout the entire project lifecycle, including project planning, operation, and maintenance. In the design, construction, application, and maintenance process, there has been a significant change in previous models and methods, including project information sharing, coordination, communication, cost control coordination, visualization of virtual conditions, informatization of data distribution, rational utilization of energy, and analysis of energy consumption. This greatly improves the efficiency and social and economic benefits of labor, materials, and equipment, enabling engineering and technical personnel to correctly understand and effectively respond to various building information, And it includes the design team and construction construction. BIM provides a foundation for all participants to work together, play a role in improving production efficiency, saving costs, shortening construction time, and guiding the construction industry towards higher level new technologies in information technology. BIM will become the second revolution in the construction industry, and it is also an information revolution.

1.2 Current Development Status of China's Construction Industry

The overall profits of Chinese construction enterprises are relatively low, and further improvement in cost control capabilities is needed. According to 2018 Fortune Global 500 Rankings (Fortune,2018) , there are only 11 construction companies on the Global 500 list, of which 7 are Chinese construction companies, accounting for more than half. In 2017, the average operating income of Chinese construction enterprises was 1.65 times that of foreign construction enterprises, but the net profit of

Chinese construction enterprises was only 1.84%, less than one-third of that of foreign construction enterprises.

Figure 1.1 Statistics of the National Construction Industry

index	In 2015	In 2016	In 2017	In 2018
Number of construction enterprises (units)	80911	83017	88074	95400
Number of employees in construction enterprises (ten thousand people)	5093.67	5184.5	5529.63	5563.3
Total output value of construction industry (100 million yuan)	180757.47	193566.78	213943.56	235085.53

source: China National Bureau of Statistics (2018)

According to the above table (data source: National Bureau of Statistics), it can be seen that the total output value of the construction industry in 2018 increased by 1.32 times compared to 2015, the number of employees in construction enterprises increased by 1.09 times compared to 2015, and the number of units in construction enterprises increased by 1.18 times compared to 2015. The total output value of the construction industry has grown faster than the number of employees and units of construction enterprises. The per capita unit output value has increased from 354900 people/billion yuan in 2015 to 422600 people/billion yuan, an increase of 1.19 times.

1.3 Problems in the Development of China's Construction Industry

The digitalization of China's construction industry is still at a low level, and the profits of construction enterprises are not high. The problems of high pollution, high energy consumption, and low efficiency remain severe. To change the dilemma of the development of the construction industry, it is necessary to change the original production and management models, promote sustainable development of construction enterprises, and achieve transformation and high digitization of the construction industry.

According to the traditional architectural design and construction process, the characteristic of settlement according to the process during the construction process leads to a low level of standardization in the construction process and poor flow of construction. This is also an important reason why most digital technology can only provide specific processes, links, and technologies. The most common problem Chinese construction industry operators face is that due to the lack of linkage between project data and enterprise data, it is difficult to achieve green management for enterprises. During the construction process, the project data flow between project managers is inaccurate. It has poor timeliness, resulting in the inability to ensure the construction progress and control the project quality during the construction period. Enterprises do not have cloud storage technology. When relevant talents want to get data, they cannot get it in time and can only send it by email. However, in of information transmission, human factors have become the biggest obstacle to the true and effective transmission of information.Therefore, promoting BIM technology is urgent. Only by applying BIM technology in the architectural design and construction process, strengthening construction standardization, systematization, and integration, can the above-mentioned problems be truly solved.

1.4 Research Objective

1) To study the influencing factors and current application status of BIM technology, and determine whether BIM technology has application prospects and significance in China's construction industry.

2) To identify the application advantages of BIM technology, and help enterprises better utilize BIM technology to benefit them.

1.5 Limitations

However, there are still some shortcomings in this article's research, specifically in the following aspects:

1) Due to the use of research data from many years ago and the collection of data from institutions, there is a certain degree of delay in the data, making it difficult to guarantee the real-time nature of the research results.

2) The theoretical model of the sample is based on my actual project experience, which has certain subjective factors and limitations, resulting in certain limitations and non objectivity in the representativeness of the research results, and cannot be universally applicable to all construction projects in China.

CHAPTER 2
LITERATURE REVIEW

The related literature will be reviewed carefully. The rest of this chapter is organized as follows. Section 2.1 introduces the origin and definition of BIM. Section 2.2 introduces the advantages of BIM in site analysis, building planning, scheme demonstration, visual design, pipeline integration, collaborative design, construction progress simulation, construction site coordination, engineering quantity statistics, completion model delivery, maintenance planning, building system analysis, and other aspects. Section 2.3 provides a detailed explanation of the differences and connections between BIM and CAD. Section 2.4 provides an introduction to BIM related software.Section 2.5 introduces BIM for China's Construction on Technology Upgrading. Section 2.6 introduces the specific application of BIM in the Chinese construction industry.

2.1 BIM Technilogy

BIM was first used in the United States. In 2003, the General Services Administration (GSA) launched the national 3D-4D-BIM plan, and successively issued a series of BIM usage guidelines. In 2006, the United States Army Corps of Engineers (USACE), a federal agency, developed and released a 15-year (2006-2020) BIM roadmap. In 2007, the American Academy of Building Sciences released the NBIMS, and its Building SMART Alliance (BSA) undertook the BIM research work. In 2008, BSA already has a series of application standards such as IFC (Industry Foundation Classes) standard, NBIMS, United States National CAD Standard and Journal of Building Information Modeling (He and Qian, 2012).

Autodesk introduced the BIM concept to the Chinese market in 2002.The research work of BIM has begun to be fully carried out in software companies, design units, real estate developers, major universities and construction units, which has made BIM develop greatly in China. In recent years, governments at all levels and related enterprises, units, and research institutions have paid more and more attention to the development of BIM, and BIM has been included in the national "Eleventh

Five-Year" and "Twelfth Five-Year" key development projects. Various provinces and cities have also successively introduced policies and measures related to BIM. With the strong support of the state, the development of BIM will take a higher level.

BIM is a data tool used in engineering design and construction management. Through parametric model synthesis, the relevant information of various projects can be shared and transmitted throughout the project planning, operation, maintenance etc. Significantly change the previous models and methods in design, construction, operation and maintenance, and carry out project information sharing, coordination, communication, coordination cost control, visualization of virtual conditions, informatization of data distribution, rational use of energy and analysis of energy consumption. Improve the efficiency and social and economic benefits of labor, materials and equipment, so that engineering and technical personnel can correctly understand and effectively respond to various building information, including design teams and construction. BIM provides the basis for all participants to work together, improves production efficiency, saves costs, shortens construction time, and guides new technologies at a higher level of information technology in the construction industry (He,2010).

BIM technology simulates the real information of buildings through digital information simulation, including non-geometric information such as strength, performance, heat transfer coefficient, component price, and material information. BIM builds a virtual architecture inside the computer through digital technology, which constitutes a building information database.

The core of BIM technology includes not only the architect's design information, but also the entire process information from the design cycle to the construction, including all data including the end of the service cycle. All these kinds of information are built in a database of 3D models of buildings. It provides continuous and timely project design scope, schedule, and cost information that is complete, reliable, and coordinated.

2.2 Advantages and Characteristics of BIM

As the core technology of Digital transformation, BIM technology, combined with other digital technologies, will be the core technology support to promote the Digital transformation and upgrading of enterprises. The information exchange mode, working mode and management mode of each participant on the construction site will be changed under the integrated application of "Internet of Things", "mobile technology", "BIM+cloud platform", "artificial intelligence", "BIM and big data", and finally form the innovation management mode of "BIM+project management".

The technical and management advantages of BIM technology are mainly reflected in the following design stages.

1) Site analysis

The main purpose of on-site analysis is to investigate the location of buildings. He is the process of establishing a relationship between buildings and the surrounding landscape. In the planning stage, foundation, vegetation, and climate conditions are important factors that affect design decisions. It is often necessary to evaluate and analyze various influencing factors such as landscape planning, environmental conditions, construction support, and traffic flow through on-site planning. Through the powerful functions of BIM and GIS software, we can timely and quickly evaluate the site based on the conditions and characteristics of the project stage, and obtain convincing analysis results. We will make decisions on site planning, traffic organization, site layout, etc.

2) Architectural planning

By analyzing the space during the construction planning phase, BIM can help project personnel understand complex spatial benchmarks and rules. Especially when discussing requirements with the construction party and selecting the best solution for analysis, BIM related analysis data can be used to make decisions and choose the best solution. Designers can use the application results of BIM in the architectural planning stage to check at any time whether the preliminary design meets the requirements of the construction party and meets the design basis. Continuous information feedback through BIM can save a lot of personnel and time.

3) Scheme argumentation

During the scheme argumentation stage, project investors can use BIM to evaluate the layout, visual, lighting, safety, ergonomics, acoustics, texture, color, and other design schemes of the project. BIM can even be used to analyze the detailed situation of buildings and analyze problems that may need to be addressed in design and construction. During the scheme argumentation stage, BIM can also be used to provide convenient and low-cost solutions for project investors. After data comparison and simulation analysis, the advantages and disadvantages of different schemes are identified to help the construction party quickly evaluate and achieve the effect of saving construction investment costs and time. Designers can evaluate the design space to obtain feedback from users and builders, and make timely changes based on feedback from end users. Under the BIM platform, the focus issues of all participating units in the project will be visualized and a consensus will be reached immediately, resulting in reduced decision-making time compared to before.

4) Visual design

Figure 2.1 BIM Visualization Design

3D visual design software such as 3Dmax and Sketch Up breaks down communication barriers between developers, end users, and designers. However, due to the design philosophy and functional boundaries of these software, there is a significant gap between the current display of three-dimensional visual effects and actual design techniques. But with the emergence of BIM, designers not only have 3D visual design tools, but also can use 3D thinking patterns to complete architectural design, enabling builders and end users to truly eliminate the limitations of technical barriers.

5) Pipeline integration

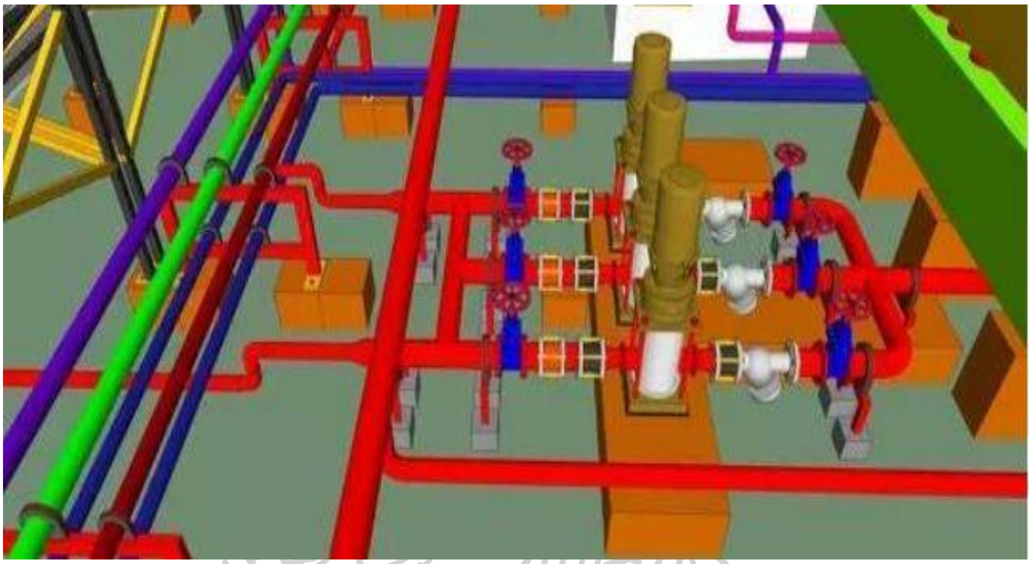

Figure 2.2 BIM pipeline integration

With the increase of building scale, its functions are becoming increasingly complex, and the integration requirements for mechanical and electrical pipelines by design units, construction enterprises, and construction units are also becoming stronger. When using traditional CAD to draw drawings, the design unit is mainly guided by various professionals to print sulfuric acid drawings. Due to the lack of information integration and intuitive communication platforms in two-dimensional drawings, pipeline integration often conflicts with building structures. By using BIM technology from various fields and assembling BIM models, designers can easily identify conflicts in design, thereby greatly improving the comprehensive design ability and work efficiency of pipelines.

6) Collaborative design

Collaborative design is a new method of architectural design that can connect different designers from different geographical locations to work together through the network. Collaborative design is a product that combines the rapid development of digital architectural design technology and network technology. The existing collaborative design is mainly based on CAD platforms, which cannot fully achieve information exchange between domains. The emergence of BIM technology has greatly improved the foundation and technical content of collaborative design. Based on the technological advantages of BIM, the scope of joint operations has expanded from a simple design phase to the overall lifecycle of the building.

7) Construction progress simulation

Engineering construction is a very dynamic process. With the expansion of construction project scale and the increase of complexity, construction project management has become very complex. By linking construction progress and BIM, spatial and temporal information can be integrated into the visual 4D (3D+TIME) model. Construction simulation technology can reasonably formulate construction schedule plans, accurately grasp construction progress, optimize the use of construction resources, scientifically manage pipeline sites, allocate resources reasonably, and ensure project quality. Greatly shorten construction time, reduce costs, and improve quality. With the support of the 4D model, the construction unit has gained a competitive advantage in project bidding. BIM can help bidding units quickly understand the main construction methods, control methods, construction layout, and overall planning of bidding units from the 4D model.

Figure 2.3 BIM construction progress simulation

8) Construction site coordination

BIM not only integrates complete information of buildings, but also provides a three-dimensional communication environment. Compared to previous models, communication efficiency has significantly improved. BIM has gradually become a communication platform among all relevant personnel on the construction site. At the same time, it can easily adjust project plans, display project manufacturing possibilities, reduce potential risks within time, shorten construction time, reduce costs through design adjustments, and improve production efficiency on the construction site.

9) Engineering quantity statistics

When using CAD drawings, regardless of the analysis software, relevant data must be manually entered for analysis and calculation. Moreover, the operation and use of these software require specialized technical personnel, requiring a significant amount of time to adjust design plans, and also requiring a significant amount of effort for data input work. When using BIM technology for design, designers can directly assign relevant characteristics to building components such as structural dimensions, material properties, and material properties at the beginning of model creation. Later, as long as they import them into the performance analysis software associated with the model, they can obtain corresponding analytical results.

10) As built model delivery

The building, as a complete system, must be checked and debugged in order to confirm that the building can play its design function when the construction sequence is completed and can be used. After the project is completed, not only traditional design and assembly drawings are required, but also relevant documents and data that can accurately reflect the actual equipment status, equipment usage, and maintenance. BIM can organically construct spatial information and equipment parameter information, so that participants can obtain complete building information. BIM can integrate information recorded during the construction process with hidden project data, which not only facilitates future asset management, but also provides effective historical information and a basis for future innovation for builders and users.

11) Maintenance plan

During the service life of the building, it is necessary to maintain the structural facilities and equipment of the building in good condition, and continuous maintenance must be carried out. A good maintenance plan can improve the performance of buildings, reduce energy consumption, and reduce maintenance costs. The BIM model that combines operation and maintenance management systems can perfectly integrate spatial positioning and data recording, create reasonable maintenance plans, and allocate maintenance personnel. For important equipment, it is possible to track the history of maintenance operations and determine the applicable status of the device in advance.

12) Building system analysis

Building system analysis is about the analysis of energy consumption, internal and external airflow simulation, and lighting simulation of buildings. It is the process of assessing whether the performance and mechanical system operation methods of a building meet the requirements of usage and design specifications. Whether designers design buildings according to design specifications and sustainable standards can also be checked and confirmed through BIM. At the same time, based on the analysis and simulation results, it can be clarified how to modify system parameters, in order to modify the system and achieve the effect of improving the overall performance of the building.

2.3 Differences and Connections between BIM and CAD

BIM technology has influenced the entire construction industry, giving new concepts to the construction industry, construction technology, and construction processes. BIM extends the traditional CAD software from a single drawing field to more aspects, such as engineering cost and schedule management, including future operation, maintenance, and other functions. There are four differences and connections between BIM and CAD.

1) Performance

The representation of CAD is basically two-dimensional, conveying relevant information to all parties involved in project construction through the concepts of points, lines, and surfaces. The information is highly specialized and requires strong professional knowledge, which is difficult for laypeople to understand. BIM can construct 3D visualization models through software, making the spatial relationships, equipment and facility locations of projects clearer and clearer. Moreover, due to the digitization and parameter technology of BIM, the data information of various components in the project can also be included. The entire building can not only represent the geometric characteristics within the space, but also the physical and functional characteristics of the building. Even personnel lacking relevant professional knowledge can understand drawings through building elements.

2) Changes

If there are changes to the CAD drawing or adjustments to the position and size of drawing elements, it is necessary to redraw the drawing. BIM technology adopts parameter modeling, and all components have rich architectural information and attributes. If modifications are needed, simply make changes to the attributes, such as adjusting the size, color, style, etc. of the components at will.

3) Correlation

Relevance is also a major feature of BIM technology. CAD technology is complex and difficult to understand due to its lack of this feature. Especially in large and complex structural projects, if it is found that the design is unreasonable and needs to be modified during the project implementation process, a large amount of personnel time needs to be invested to change the relevant graphic components. The BIM technology components have a high degree of correlation. If there is a problem with the component, only the attributes need to be adjusted, and the relevant components will automatically match and apply according to the modified location. For example, after adjusting the ceiling height in BIM software, the relevant parameters of doors and windows will also be automatically adjusted accordingly. This process saves a lot of personnel and time, and also reduces the accidental errors caused by manual adjustment.

4) Informativeness

The information contained in CAD is generally represented through two-dimensional flat drawings and tables, so the information contained in CAD is relatively single and has specific timeliness; Small information capacity; Information is highly specialized and difficult to understand without professional learning and training. BIM technology is based on 3D models, which fuse and overlay drawings from different professions and periods, and assign the length of time and space to the drawings to form a visual model. So BIM technology contains comprehensive information and is suitable for the entire life cycle of building construction; Large information capacity; The information is relatively intuitive and easy to understand. If BIM technology is combined with cloud technology, the model can be stored for a long time and accessed anytime, anywhere, providing faster and more accurate information for all parties involved in the construction and making timely and reasonable decisions.

The above four aspects are the difference between BIM and CAD, and as BIM technology is applied more widely and deeply, I believe that the advantages of BIM over CAD will become more apparent.

2.4 Related BIM Softwares

1) BIM core modeling software

There are four main types of BIM core modeling software:

- Revit, outstanding features: civil architecture design, comprehensive design;

- Bentley, outstanding features: infrastructure design, comprehensive design;

- ArchiCAD, outstanding features: architectural design, easy to get started;

- CATIA, outstanding features: mechanical design, surface design.

2) BIM scheme design software

BIM design software is used in the initial stage of design. The main function is to change the project into a geometric based building plan based on the digital requirements of the construction party for the project. This plan is used for communication between the construction party and the designer, as well as for planning research and demonstration. BIM scheme design software can help designers confirm whether the design plan meets the requirements of the construction party.

Currently, there are mainly software such as Onuma Planning System and Affinity.

3) BIM Deepening Design Software

The BIM core deepening design software mainly includes the following:

- Rhino, outstanding features: curtain wall design, curved surface design;

- Tekla, outstanding features: structural design;

- MagiCAD, outstanding features: electromechanical design, based on Revit/AutoCAD;

- SketchUp, outstanding features: conceptual design, easy to get started;

- Civil 3D, prominent features: civil engineering design.

4) Structural analysis software

Structural analysis software can basically achieve bidirectional information exchange. The structural analysis software can use the BIM core modeling software information for structural analysis, and can provide feedback on the adjustment of structural analysis results to the BIM core modeling software, automatically updating the BIM model.

The main structural software at home and abroad include: PKPM; YJK ; Robot ; STAAD ; ETABS, etc.

1) Visualization software

The main advantages of visualization software are as follows:

- Visualization reduces the workload of modeling;

- The development and application of visualization software have improved the consistency between the model and the design;

- Common visualization software includes 3DSMAx, Artlantis, Ac-cuRender, Navisworks, Lumion, Fusor, and Lightscape.

2) Cost control software

Cost management software utilizes the information provided by BIM models for cost statistics and analysis. In order to support the BIM model structure data, cost management software based on BIM technology can dynamically provide the data required for cost management according to the project schedule, which is the so-called 5D application of BIM technology. Innovaya and Solibri are currently mainstream BIM cost management software abroad, with Luban being the most representative BIM cost control software in China. Luban provides an overall framework for the application of BIM based cost management solutions centered around project builders, which plays a positive role in improving the application level of BIM information in cost management. We know that with more participants and the types of work that can use BIM model information, the value of BIM can play a greater role in the project.

3) BIM model comprehensive collision inspection software

There are two reasons for the development and utilization of model comprehensive collision detection software:

- Different designers use their own BIM core modeling software to create different professional BIM models. These models must be integrated in one environment to complete the design, analysis, and simulation of the entire project. However, this integration cannot be completed in the BIM core modeling software, so it is necessary to develop and utilize BIM model comprehensive collision checking software.

- In large projects, due to hardware limitations, BIM core modeling software cannot operate on the entire project model within a single file alone, but can create these local models separately. So when it is necessary to study the design, construction, and status of the entire project, specialized software needs to be developed. The basic function of the model comprehensive collision inspection software is to further deepen the 3D model, such as 3D coordination, 4D planning, visualization, dynamic simulation, etc. Common comprehensive collision checking software for models includes Autodesk; Navisworks ; Bentley ; Projectwise ; Navigator and Solibri Model Checker, etc.

4) Operations management software

According to the National BIM Standards Committee in the United States, the cost of the construction phase only accounts for 25% of the total cost of the building's lifecycle, while the cost incurred during the use phase accounts for 75% of the total cost of the building's lifecycle. The cost control during the use phase of the building has significant economic benefits, which has become an important driving force for the BIM model to serve the operation and management phase of the building. Common operational management software includes ARCHIBUS; Autodesk FM Desktop and ArchiFM.

2.5 BIM for China's Construction Technology Upgrading

BIM technology is of great significance for the technological upgrading of China's construction industry, and governments at all levels have successively introduced relevant policies to increase research and promotion of BIM technology.

The Outline for the Development of Construction Industry Informatization in 2016-2020 issued by the Ministry of Housing and Urban Rural Development proposed to promote the transformation and upgrading of "Internet plus" and the construction industry. Special requirements have been made for the implementation plan of building informatization: during the 13th Five Year Plan period, efforts should be made to improve the comprehensive information technology level of the construction industry, strengthen the integration of information technologies such as BIM, big data, intelligence, mobile communication, cloud computing, and the Internet of Things, and improve application capabilities. We need to build a digital, networked, and intelligent construction industry, and initially establish an integrated industry supervision and service platform. Fully utilizing data resources and enhancing information service capabilities, gradually forming a construction information technology enterprise that can effectively utilize information technology, has the ability to develop and research information technology, possesses independent intellectual property rights, and reaches the international advanced level.

On June 16, 2015, the Ministry of Housing and Urban Rural Development issued the "Guiding Opinions on Promoting the Application of Building Information Models", in which specific promotion goals were specified: by the end of 2020, Grade

A survey and design units in the construction industry, as well as special and first-class housing construction enterprises, need to master BIM related technologies; The proportion of large and medium-sized projects using BIM technology integration applications reaches 90%, mainly in the fields of large and medium-sized buildings invested by state-owned funds, green building application public buildings, and green ecological demonstration. This goal provides a reference basis for governments and regions at all levels to promote BIM policies in the future. Under the influence of relevant policies, various provinces and regions such as Beijing, Guangxi, Zhejiang, Yunnan, Liaoning, Heilongjiang, Hunan, and Shanghai have issued guidance on the application of BIM technology.

For enterprises, by applying BIM technology, real-time sharing and business collaboration of technical, business, and production data can be achieved, ensuring data consistency and accuracy. It has achieved efficient collaboration between enterprises and projects, and improved the standardization, refinement, and intensive management capabilities of enterprises for projects. As the first simulation experiment, BIM can integrate models, engineering information, and management information throughout the entire construction lifecycle.

From the development of digital technology, on the basis of the popularization of new client technologies such as the Internet and mobile applications, cloud computing, big data, and other server technologies. Timely release and access project website data and information at any time, thus forming a "cloud+" application model. The multi-party coordination application mode based on the network and BIM technology have achieved real-time collaboration, sharing of all participants on the website, and playing an important role in real-time monitoring of on-site management processes, forming complementary advantages. Integrate BIM and project management system applications, improve and share data between business units during project management, effectively promote technology, production, and business management connectivity and collaboration, and support optimization planning. Effectively control design changes, reduce rework, reduce costs, improve the quality of the implementation process, and significantly reduce the risk of contract execution.

2.6 Specific Application of BIM in China's Construction Industry

With the widespread application of BIM technology in the construction industry, the traditional engineering cost industry is bound to be fiercely impacted and challenged. According to a survey by McKinsey Global Research Institute, investment in technology research and development in the construction industry is less than 1%, far lower than 3.5% in the automotive industry and 4.5% in the aviation industry. In the past 20 years, based on the proportion of investment in simulated production and automated machines in the manufacturing industry, the technology research and development investment in the construction industry should reach 3%, which means there is a 70 billion dollar technology research and development market in the construction industry.

In recent years, a large number of projects in China have also adopted BIM technology. Due to its complex structure, the Beijing Olympic Water Cube adopted BIM technology in the steel structure design phase to achieve coordinated and consistent design content; Through BIM technology, accelerate engineering information communication, ensure the accuracy of engineering information, and shorten the construction cycle. Due to the extensive use of prefabricated concrete components, the Vanke Golden Mileage adopts BIM technology in the 3D model wall design and comprehensive architectural design stages, ensuring a clear and clear relationship between the walls; Shorten the construction cycle. Shanghai center Building is a super high-rise building, and the coordination workload between different disciplines is heavy, so BIM technology is implemented throughout the life cycle of the building. The detailed architectural information of the 3D model provides a foundation for deepening the design, while also promoting collaborative work. Shanghai Disneyland has many classic Disney story cartoon characters, castles, gardens, lakes, and other irregular buildings, so BIM technology has been adopted throughout the entire life cycle of construction to reduce engineering costs, save construction costs, and provide effective information required for operation and management; Create a unique charm of the park. In addition to the above projects, BIM construction technology has been adopted for the Zhonghua Zun, Hong Kong

Zhuhai Macao Bridge, Beijing New Airport, and recently built Huoshen Mountain and Leishen Mountain Hospitals in Wuhan.

According to the "2018-2023 China Building Information Model (BIM) Market Outlook and Investment Strategy Planning Analysis Report", the proportion of building information model application projects in China in 2016 was only 30% - 40%, which is still far from the 90% target required by the Ministry of Housing and Urban Rural Development in the "Guiding Opinions on Promoting the Application of Building Information Models". We should continue to increase the promotion and application of BIM technology.

CHAPTER 3
RESEARCH METHODOLOGY

This chapter introduces the research design and its research methods. Research design can be developed based on research objectives.

3.1 Research Methods

This study is a feasible, targeted, and online questionnaire survey.

3.2 Research Purpose

By analyzing the application situation, influencing factors, and current situation of BIM in a specific group in the construction industry, we can determine whether BIM technology has application prospects and significance in construction. At the same time, through research and analysis, we can further understand the application advantages of BIM technology and help enterprises better use BIM technology to benefit them.

3.3 Research Process Flow Diagram

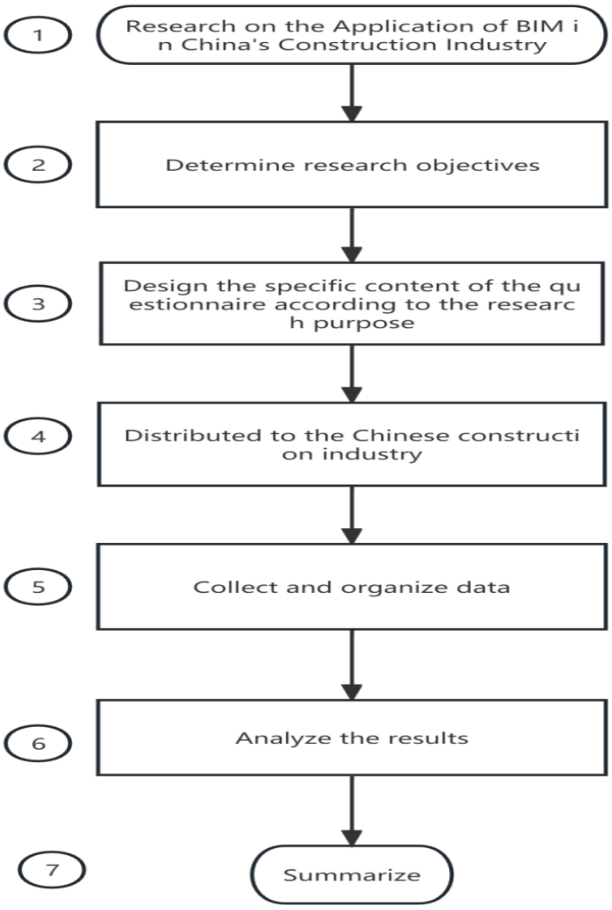

Figure 3.1 Research Process Flow Chart

3.4 A Case Study

The target group is to select representative employees from five categories of Chinese construction enterprise Yunnan Construction Investment Group Holding Co., Ltd. A leading construction enterprise in Yunnan Province of China. Employees refer to those who are engaged in specific related work in the construction industry, including investment, construction, testing, design, cost, and other work. Representative companies refer to companies whose nature covers investment, construction, testing, design, installation, or other BIM that can better reflect the application.

3.5 Sample and Population

From all employees of five representative companies, and using random sampling to select the sample size from the total number, Yunnan Construction Investment Holding Group Co., Ltd. has about 23000 employees ($n = 23000$), $n = \frac{p(1-p)}{(\frac{e^2}{z^2+\frac{P(1-p)}{n}})}$=378, so it needs a sample size of 378 participants to reach a minimum error margin of ± 5%, to ensure that each item of each tool has a 95% confidence level.

3.6 Data Collection

The survey intention was expressed to five representative companies, and they were invited to participate. After receiving the reply from the other party, the other company will distribute the questionnaire link to all employees. The questionnaire survey starts with the employee information, followed by the consent statement. The participants must agree to start the survey. The survey link is conducted on the questionnaire star platform, and the data is managed by it. The data collection time is from July to September 2023.

3.7 Questionnaire Design

The tool of this study is a questionnaire with three parts and 21 items. Part A of the questionnaire is the survey of demographic variables (3 items), Part B is to measure the application of BIM Technology in architecture (9 items), and Part C is to measure the application prospect and significance of BIM Technology in architecture (9 items).Part A and Part B is studied by the non-scale method, the C part is studied by the Likert scale method.

3.8 Validity Analysis

In order to ensure the feasibility of the study, a pre-test method will be used to conduct a small-scale experimental survey through non-random samplingto find unreasonable designs and optimize the questionnaire in time. The reliability and validity of the questionnaire were analyzed through a small sample to ensure the reliability and validity of the questionnaire.

This pre-test adopts the method of the paper questionnaire survey, which is first distributed in a construction company, and the test sample size is 60. IBM SPSS Statistics 25 software was used, and the confidence interval was 25%.

1) Reliability analysis

The reliability and validity of the pre-survey data were analyzed. Firstly, the data's reliability and validity were analyzed using Cronbach alpha. In the reliability analysis, the Cronbach alpha coefficient is generally above 0.7, which indicates that the reliability of the questionnaire is high and can be further analyzed. It can be seen from the table below that the Cronbach alpha coefficient of each dimension of the questionnaire is greater than 0.7, indicating that the overall reliability of the questionnaire is high.

Table 3.1 Reliability analysis table

Klonbach alpha	Number of items
0.931	11

Sensitivity analysis: in the last column of the table below, the "deleted Cronbach alpha coefficient" is relatively high, indicating that the topic setting is good and the consistency is high.

Table 3.2 Item total statistics

Item total statistics				
	Scale average after deleting items	Scale variance after deleting items	Corrected item and total correlation	Clone Bach alpha after deleting item
Influencing factor 1	29.77	93.029	.748	.923
Influencing factor 2	29.67	91.548	.714	.924

Table 3.2 Item total statistics (continued)

Item total statistics				
Influencing factor 3	29.67	90.802	.772	.922
Application significance1	29.70	93.908	.643	.927
Application significance2	29.83	93.124	.726	.924
Application significance3	29.92	90.823	.703	.925
Application significance4	30.08	94.179	.669	.926
Application significance5	29.78	92.817	.705	.925
prospect1	29.67	93.650	.729	.924
prospect2	29.60	93.939	.729	.924
prospect3	29.48	93.101	.725	.924

2) Validity analysis

Next, factor analysis was used for validity analysis. In validity analysis, the KMO value generally remains above 0.7, so questionnaire analysis is suitable for factor analysis. It can be seen from the table below that the KMO test value is 0.882>0.7, and the Bartlett sphericity test sig is 0.000<0.05, indicating that the data is suitable for factor analysis.

Table 3.3 The KMO and Bartlett test

KMO sampling appropriateness quantity		0.882
Bartlett sphericity test	Approximate chi square	527.714
	freedom	55
	significance	0.000

It can be seen from the table below that the total variance explained is 80.569%, which means that the factor interpretation ability is good. The extracted three factors can retain most of the original information.

Table 3.4 Total variance explanation

component	initial eigenvalue			Sum of squares of extracted loads			Sum of squares of rotating loads		
	total	Variance percentage	Cumulative%	total	Variance percentage	Cumulative%	total	Variance percentage	Cumulative%
1	6.535	59.413	59.413	6.535	59.413	59.413	3.328	30.252	30.252
2	1.222	11.109	70.522	1.222	11.109	70.522	2.780	25.272	55.524
3	1.105	10.047	80.569	1.105	10.047	80.569	2.755	25.045	80.569
4	0.513	4.668	85.237						
5	0.493	4.480	89.717						
6	0.336	3.054	92.771						
7	0.252	2.295	95.066						
8	0.156	1.415	96.481						
9	0.145	1.320	97.801						
10	0.129	1.170	98.971						
11	0.113	1.029	100.000						

It can be seen from the table below that the dimension discrimination is good, and the load of each factor falls on the corresponding dimension.

Table 3.5 Rotated component matrix A

	Composition		
	1	2	3
Influencing factor 1			0.842
Influencing factor 2			0.884
Influencing factor 3			0.843
Application significance 1	0.775		
Application significance 2	0.695		
Application significance 3	0.783		
Application significance 4	0.777		
Application significance 5	0.749		
Foreground1		0.875	
Foreground2		0.859	
Foreground3		0.824	

On the whole, the whole questionnaire has high reliability and validity, is reliable and effective, and can be used for research and analysis.

3.9 Statistical Analysis

The research data will be downloaded from the questionnaire star platform. SPSS software will be used for data analysis.

1) According to the classified data of the questionnaire, the nature of the company in which part A is located, the number of years engaged in the construction industry, and the highest level of education, and part B is constructed from the service life, projects, reasons, and related software and technology development factors, all of which will be described in terms of frequency counts and percentages.

2) The questionnaire contains continuous data. Part C is constructed from three parts.

- Factors affecting the development of BIM Technology: user willingness, convenience of relevant software, and difficulty of software learning. The three factors affect each other.

- The application significance of BIM: the role of BIM in work efficiency, the role of reducing costs for enterprises, the role of improving management efficiency, the role of improving design efficiency, construction site analysis， and site communication and coordination. The application significance of BIM Technology in all aspects of the construction industry is obtained from different application methods.

- BIM Technology Development Prospect: Software research and development, mainstream technology, and sustainable development ability, all of which make research and judgment on the future development trend of BIM Technology.

CHAPTER 4
RESULTS AND ANALYSIS

4.1 Variable Definition

A total of 378 participants were invited to participate in the survey.

Table 4.1 Variable Definition

Variable		Define	
Control Variable	Company Nature	1=Investment Company, 2=Construction Company, 3=Design Company, 4=Supervision Company, 5=Testing Company	Categorical Variable
Control Variable	Years of service	1=Within 1 Year, 2=1-5 Years, 3=6-10 Years, 4=11-15 Years, 5=16-20 Years, 6=Over 20 Years	Categorical Variable
Control Variable	Education	1=PhD, 2=Master's, 3=Undergraduate, 4=Junior College, 5=Other	Categorical Variable
Control Variable	Whether To Apply	0=No, 1=Yes	Categorical Variable
Argument	Contact Duration	1=Over 5 Years, 2=3-5 Years, 3=1-5 Years, 4=Just Contacted, 5=Never Heard Of	Categorical Variable
Argument	Number Of Items Used	1=10 Or More Projects, 2=5-10 Projects, 3=1-5 Projects, 4=Never Used	Categorical Variable
Argument	Influence 1	This section is a scale question, with a score of 1-5. The higher the score, the higher the willingness or recognition	Quantitative variables of the scale

Table 4.1 Variable Definition (continued)

Variable		Define	
Argument	Influence 2		Quantitative variables of the scale
Dependent Variable	Influence 3		Quantitative variables of the scale
Dependent Variable	Significance 1		Quantitative variables of the scale
Dependent Variable	Significance 2		Quantitative variables of the scale
Dependent Variable	Significance 3		Quantitative variables of the scale
Dependent Variable	Significance 4		Quantitative variables of the scale
Dependent Variable	Significance 5		Quantitative variables of the scale
Dependent Variable	Prospect 1		Quantitative variables of the scale
Dependent Variable	Prospect 2		Quantitative variables of the scale

Table 4.1 Variable Definition (continued)

Variable		Define	
Dependent Variable	Prospect 3		Quantitative variables of the scale
Dependent Variable	Influence	Take the average value of this dimension	Quantitative variables of the scale
Dependent Variable	Significance	Take the average value of this dimension	Quantitative variables of the scale
Dependent Variable	Prospect	Take the average value of this dimension	Quantitative variables of the scale

Using Software: IBM SPSS Statistics 25, Confidence Interval 25%.

4.2 Reliability Analysis

Conduct reliability and validity analysis on the pre survey data. Firstly, conduct reliability and validity analysis, and use Clonbach Alpha to analyze the data reliability. In reliability analysis, the Clonbach Alpha coefficient generally reaches above 0.7, indicating a high reliability of the questionnaire, which can be further analyzed. From the table below, it can be seen that the Clonbach Alpha coefficient of each dimension in this study questionnaire is greater than 0.7, indicating a high overall reliability of the questionnaire.

Table 4.2 Reliability Analysis

dimension	Clone Bach Alpha	Number of items
Factors affecting the development of BIM technology	0.771	3
The Application Significance of BIM	0.863	5
Development prospects of BIM technology	0.784	3
Scale	0.868	11

Sensitivity analysis: In the last column of the table below, the "deleted Clonbach Alpha coefficient" is relatively high, indicating good question setting and high consistency.

Table 4.3 Total Item Statistics

	Scale average after deleting items	Scale variance after deleting items	Corrected item and total correlation	Clone Bach Alpha after deleting item
Influencing factor 1	30.0899	64.262	0.508	0.861
Influencing factor 2	30.1772	64.762	0.526	0.860
Influencing factor 3	30.1058	66.259	0.446	0.865
Application significance 1	30.1852	61.488	0.652	0.850
Application significance 2	30.1799	62.609	0.613	0.853
Application significance 3	30.2037	63.096	0.609	0.854

Table 4.3 Total Item Statistics (continued)

	Scale average after deleting items	Scale variance after deleting items	Corrected item and total correlation	Clone Bach Alpha after deleting item
Application significance 4	30.1931	61.090	0.673	0.849
Application significance 5	30.2275	62.818	0.652	0.851
Foreground1	30.1931	63.854	0.551	0.858
Foreground2	30.2249	64.795	0.512	0.861
Foreground3	30.1772	65.122	0.492	0.862

4.3 Validity analysis

Next, use factor analysis method for validity analysis. In validity analysis, generally speaking, if the KMO value remains above 0.7, questionnaire analysis is suitable for factor analysis. From the table below, it can be seen that the KMO test results in values of 0.882>0.7, and the Bartlett sphericity test Sig is 0.000<0.05, indicating that the data is suitable for factor analysis.

Table 4.4 KMO and Bartlett inspection

KMO sampling appropriateness quantity		0.882
Bartlett sphericity test	Approximate chi square	1646.146
	freedom	55
	significance	0.000

From the table below, it can be seen that the total variance explained is 67.353%, indicating a good ability to explain factors. The three extracted factors can retain most of the original information.

Table 4.5 Total Variance Explanation

component	initial eigenvalue			Sum of squares of extracted loads			Sum of squares of rotating loads		
	total	Variance percentage	Cumulative %	total	Variance percentage	Cumulative %	total	Variance percentage	Cumulative %
1	4.789	43.532	43.532	4.789	43.532	43.532	3.132	28.476	28.476
2	1.409	12.809	56.342	1.409	12.809	56.342	2.167	19.697	48.174
3	1.211	11.011	67.353	1.211	11.011	67.353	2.110	19.179	67.353
4	0.549	4.987	72.340						
5	0.521	4.741	77.080						
6	0.507	4.611	81.691						
7	0.488	4.432	86.123						
8	0.422	3.833	89.956						
9	0.400	3.640	93.596						
10	0.378	3.432	97.028						
11	0.327	2.972	100.000						

From the table below, it can be seen that the dimension differentiation is good, and the load of each factor falls on the corresponding dimension. Overall, the questionnaire has high reliability and validity, is reliable and effective, and can be used for research and analysis.

Table 4.6 Rotated Component Matrix A

	Composition		
	1	2	3
Influencing factor 1			0.797
Influencing factor 2			0.795
Influencing factor 3			0.797
Application significance 1	0.770		
Application significance 2	0.796		
Application significance 3	0.767		
Application significance 4	0.752		

Table 4.6 Rotated Component Matrix A (continued)

	Composition		
	1	2	3
Application significance 5	0.710		
Foreground1		0.795	
Foreground2		0.805	
Foreground3		0.797	

4.4 Descriptive Statistics

Describe and count the basic information in the questionnaire.

Table 4.7 Basic Information Statistics Table

	Grouping	Frequency	Percentage (%)
Company Nature	1	86	22.8
	2	112	29.6
	3	98	25.9
	4	39	10.3
	5	43	11.4
Years of service	1	36	9.5
	2	42	11.1
	3	108	28.6
	4	65	17.2
	5	78	20.6
	6	49	13.0

Table 4.7 Basic Information Statistics Table (continued)

	Grouping	Frequency	Percentage (%)
Education	1	17	4.5
	2	56	14.8
	3	224	59.3
	4	68	18.0
	5	13	3.4
Whether To Apply	0	26	6.9
	1	352	93.1
Contact Duration	1.00	51	13.5
	2.00	78	20.6
	3.00	169	44.7
	4.00	69	18.3
	5.00	11	2.9
Number Of Items Used	1.00	78	20.6
	2.00	86	22.8
	3.00	102	27.0
	4.00	112	29.6
	5.00	199	52.6

Table 4.8 Descriptive Statistics (Multiple Choice)

Variable	Classification	Number Of Cases	Percentage	Case Percentage
What is the reason for using BIM technology	Question 7.1	102	18.8%	53.7%
	Question 7.2	83	15.3%	43.7%
	Question 7.3	67	12.3%	35.3%
	Question 7.4	76	14.0%	40.0%
	Question 7.5	86	15.8%	45.3%
	Question 7.6	67	12.3%	35.3%
	Question 7.7	62	11.4%	32.6%
Which BIM technology software have you used	Question 8.1	100	13.2%	52.6%
	Question 8.2	93	12.3%	48.9%
	Question 8.3	99	13.0%	52.1%
	Question 8.4	96	12.6%	50.5%
	Question 8.5	96	12.6%	50.5%
	Question 8.6	96	12.6%	50.5%
	Question 8.7	98	12.9%	51.6%
	Question 8.8	81	10.7%	42.6%
What assistance can BIM technology provide for architectural design	Question 9.1	154	24.8%	80.2%
	Question 9.2	112	18.1%	58.3%
	Question 9.3	101	16.3%	52.6%
	Question 9.4	121	19.5%	63.0%
	Question 9.5	132	21.3%	68.8%

Table 4.8 Descriptive Statistics (Multiple Choice) (continued)

Variable	Classification	Number Of Cases	Percentage	Case Percentage
What help do you think BIM technology can provide for building construction	Question 10.1	154	25.5%	81.1%
	Question 10.2	90	14.9%	47.4%
	Question 10.3	118	19.5%	62.1%
	Question 10.4	103	17.1%	54.2%
	Question 10.5	139	23.0%	73.2%
What aspects of support do you think the promotion of BIM technology requires	Question 11.1	154	21.9%	81.1%
	Question 11.2	159	22.6%	83.7%
	Question 11.3	118	16.8%	62.1%
	Question 11.4	140	19.9%	73.7%
	Question 11.5	131	18.7%	68.9%
What issues do you think need to be addressed in the promotion process of BIM technology	Question 12.1	167	19.3%	87.9%
	Question 12.2	136	15.7%	71.6%
	Question 12.3	139	16.1%	73.2%
	Question 12.4	118	13.6%	62.1%
	Question 12.5	127	14.7%	66.8%
	Question 12.6	178	20.6%	93.7%

Table 4.9 Dimension Mean Description Statistics

	N	Minimum Value	Maximum Value	Mean Value	Standard Deviation
Influencing factor	378	1.00	5.00	3.07	0.989
Application significance	378	1.40	5.00	3.01	0.858
Foreground	378	1.00	5.00	3.00	1.001

4.5 Difference

Perform independent sample t-tests on the following data based on the data type.

Table 4.10 t-Test Difference Table

Dimension	Grouping	Individual Cases	Average Value	Standard Deviation	t	P
Influencing factor	0	179	1.92	0.707	-8.352	0.000
	1	199	3.16	0.953		
Application significance	0	179	2.1	0.651	-7.273	0.000
	1	199	3.08	0.833		
Foreground	0	179	2.12	0.997	-4.680	0.000
	1	199	3.06	0.972		

Perform independent sample chi square tests on the following data based on the data type.

Table 4.11 Chi Square Test Difference

Dimension	Grouping	Whether to apply		Chi square value	P
		0	1		
Company Nature	1	5	81	6.301	0.178
		5.8%	94.2%		
	2	10	102		
		8.9%	91.1%		
	3	6	92		
		6.1%	93.9%		
	4	5	34		
		12.8%	87.2%		
	5	0	43		
		0.0%	100.0%		
Years of service	1	7	29	20.298	0.001
		19.4%	80.6%		
	2	4	38		
		9.5%	90.5%		
	3	8	100		
		7.4%	92.6%		
	4	7	58		
		10.8%	89.2%		
	5	0	78		
		0.0%	100.0%		
	6	0	49		
		0.0%	100.0%		

Table 4.11 Chi Square Test Difference (continued)

Dimension	Grouping	Whether to apply		Chi square value	P
		0	1		
Education	1	5	12	14.874	0.005
		29.4%	70.6%		
	2	4	52		
		7.1%	92.9%		
	3	11	213		
		4.9%	95.1%		
	4	5	63		
		7.4%	92.6%		
	5	1	12		
		7.7%	92.3%		
Whether To Apply	1	11	40	21.834	0.000
		21.6%	78.4%		
	2	5	73		
		6.4%	93.6%		
	3	9	160		
		5.3%	94.7%		
	4	1	68		
		1.4%	98.6%		
	5	0	11		
		0.0%	100.0%		

Table 4.11 Chi Square Test Difference (continued)

Dimension	Grouping	Whether to apply		Chi square value	P
		0	1		
Contact Duration	1	7	71	3.051	0.384
		9.0%	91.0%		
	2	6	80		
		7.0%	93.0%		
	3	9	93		
		8.8%	91.2%		
	4	4	108		
		3.6%	96.4%		
	5	26	173		
		13.1%	86.9%		

4.6 Related Analysis

Table 4.12 Related Analysis Table

		Influencing factor	Application significance	Foreground
Influencing factor	Pearson Correlation	1		
Application significance	Pearson Correlation	0.482**	1	
Foreground	Pearson Correlation	0.327**	0.659**	1
At the 0.01 level (double tailed), the correlation is significant.				

4.7 Regressive Analysis

According to the table below, it can be seen that the significance P=0.000<0.05 indicates that the equation has statistical significance.

Table 4.13 Hosmer Lemeshoe Test

Chi-Square	Freedom	Significance
72.012	7	0.000

According to Table 3.19, it can be seen that the overall prediction accuracy is as high as 95.5%, indicating a high fitting degree of the equation.

Table 4.14 Classification

		Whether To Apply		Correct Percentage
Actual Measurement		0	1	
Whether To Apply	0	10	16	38.5
	1	1	351	99.7
Overall Percentage				95.5

Table 4.15 Variables in the equation

	B	Error	Wald	Freedom	Significance	Exp(B)（OR）
Years of service	0.484	0.217	4.991	1	0.025	1.622
Education	0.165	0.233	0.500	1	0.480	1.179
Whether To Apply	0.446	0.294	2.306	1	0.129	1.562
Contact Duration	0.492	0.244	4.080	1	0.043	1.636
Influencing factor	1.460	0.399	13.360	1	0.000	4.304
Application significance	1.137	0.489	5.411	1	0.020	3.116
Foreground	0.344	0.386	0.797	1	0.372	1.411
Constant	-8.690	1.959	19.667	1	0.000	0.000

From the table above, it can be seen that:

- According to column 'B', an equation can be constructed;

F (Application or not)=0.484 * Years of service+0.165 * Education

+0.446 * Whether To Apply+0.492 * ontact Duration+1.460 * Influencing factor+1.137 * Application significance+0.344*Foreground -8.690

Because some variables in the equation have a significance greater than 0.05, coupled with the limitations of questionnaire design, it is recommended that the equation be used only as an explanatory model for explanation and not for prediction.

- Among them, the three dimensions of being Influencing factor, Application significance, and Foreground passed the significance test;

- According to the Exp (B) value, it can be seen that Application significance has the greatest impact on the dependent variable, followed by Influencing factor

- Provide a specific explanation for the OR value, as the model contains insignificant variables. Based on the purpose of the article, this regression is defined as explanatory regression analysis (not used as a prediction).

CHAPTER 5

CONCLUSION

This survey further deepens our research on the application, influencing factors, and current status of BIM technology. Although the results are exploratory, the research findings indicate that strengthening user willingness, improving the convenience of related software, and reducing the difficulty of software learning can better assist the development of BIM technology. BIM technology has significant advantages in increasing work efficiency, helping enterprises reduce costs, improving management efficiency, improving design efficiency, analyzing construction sites, and coordinating on-site communication. BIM technology has significant application prospects and significance in the Chinese construction industry. In the future, China can strengthen software research and development of BIM technology, enhance mainstream technology, and enhance sustainable development capabilities, and better utilize BIM technology to promote the vigorous development of China's construction industry and enterprises.

REFERENCES

Dorozhkina, E. (2022). Features of interaction of participants in the construction of transport infrastructure facilities at the stage of implementing BIM technologies. In **Transportation Research Procedia** (Vol. 63, pp. 2703-2709).

Fengqi, W. (2019). "Peng Shuning. Investigation and Analysis of BIM Application in Chinese Construction Enterprises." **Construction Technology**, 50, 04: 451-454.

Guanglianda Technology Co., Ltd. (2020). "Analysis of the Current Situation of BIM Application in China's Construction Industry." **Build**, 2020, 15: 28-31.

Guanpei, H. (2010). "The Position,Evaluation System,and Possible Application of BIM in the Construction Industry." **Civil Engineering Information Technology**, 2, 1: 109-116.

———. (2012). "BIM and BIM related software." **Civil Engineering Information Technology**, 4, 2: 110-117.

Henry, R. L. (2018). **World Top 500 Rankings**. Fortune.

Hongya, F. (2023). "Analysis of BIM Technology Application in Construction Project Information Management." **China Construction Informatization**, 184, 09: 82-86.

Huajing Industrial Research Institute. (2023). **Research Report on the Market Development Status and Investment Direction of China's Construction Informatization Industry from 2023 to 2028**. accessed January 16, 2023. available from https://m.huaon.com/detail/864306.html,Reportnumber:864306

Huichen, W. (2022). "Research on the Application of BIM Technology in the Construction Industry." **Sichuan Building Materials**, 48, 07: 37-39.

Jianping, Z. (2012). "The Application of BIM in Engineering Construction." **Construction Technology**, 41, 371: 10-17.

Jiayi, P., and Yuanyu, Z. (2012). "Research on Barriers of BIM Application in China’s Building Industry." **Journal of Engineering Management**, 2012, 01: 6-11.

Jing, H., and Mingxia, X. (2017). "A Brief Discussion on the Current Situation of BIM Technology Application in Construction Industry Information Management." **Science and Technology Innovation**, 2017, 34: 99-100.

Jingjian, C. (2022). "BIM Helps Improve the Informatization Level of the Construction Industry." **China Industry and Information Technology**, 43, Z1: 54-58. doi:10.19609/j.cnki.cn10-1299/f.2022.z1.003

Kim, Y., Chin, S., and Choo, S. (2022). BIM data requirements for 2D deliverables in construction documentation. In **Automation in Construction** (Vol. 140, pp. 104340).

Pereira, V., Santos, J., Leite, F., and Escórcio, P. (2021). Using BIM to improve building energy efficiency – A scientometric and systematic review. In **Energy and Buildings** (Vol. 250, pp. 111292).

Qing-Jie, W., Zi-Jian, R., Hui, L., and JiFeng, W. (2021). The progress and trend of BIM research: A bibliometrics-based visualization analysis. In **Automation in Construction** (Vol. 124, pp. 103558).

Qinghua, H., and Lili, Q. (2012). "Research on the Current Situation and Obstacles of BIM Application at Home and Abroad." **Journal of Engineering Management**, 26, 1: 13-16.

Sampaio, A. Z. (2022). Project management in office: BIM implementation. In **Procedia Computer Science** (Vol. 196, pp. 840-847).

Xia, L. (2022). "The Application of BIM Technology and Its Impact on the Development of the Construction Industry." **Chinese Market**, 1038, 11: 68, 70. doi:10.13939/j.cnki.zgsc.2020.11.068

Zhibing, M. (2022). "What changes will BIM bring to the production mode of the construction industry." **Construction Enterprise Management**, 409, 09: 67-69.

APPENDIX

Application of BIM technology in engineering construction

Dear Mr. / Madam,

shalom! I am very glad to contact you to participate in this survey. I am very grateful for your support and cooperation! This is an academic survey. The purpose of this survey is to investigate the influencing factors and application status of BIM technology, and to explore whether BIM technology has application prospects and application significance in construction weight. The survey was conducted in an anonymous manner, with no right or wrong answers. At the same time, we declare that the data collected in this survey will be used for academic research only and will only be handled by professional researchers related to the project for an overall statistical analysis. We promise that your answers will be kept absolutely confidential. Please fill in the questionnaire according to your actual situation, and do not miss the answer. The objective, truthful information you provide is critical to the validity and accuracy of the study conclusions. After completing the questionnaire, the questionnaire was returned to our researcher. If you are interested in our research topic, hoping to know more information about this aspect, you can contact us. We are like to share the research results of this topic with you. Researchers email: 779351019@qq.com

PART A

Base Situation

1. The nature of your company?[single choice]*

☐ A.investment company

☐ B.construction company

☐ C.design company

☐ D. Supervision company

☐ E. Testing company

2. How many years have you been engaged in the construction industry?[single choice]*

☐ A. Within 1 year

☐ B.1-5 Years

☐ C.6-10 Years

☐ D.11-15 Years

☐ E.16-20 Years

☐ F. More than 20 years

3. Your educational background?[single choice]*

☐ A.doctor

☐ B. Master

☐ C.undergraduate course

☐ D.junior college education

☐ E.other

PART B

Investigation on the application of BIM technology in the construction industry

4. Has your company ever used BIM technology?[single choice]*

☐ A.yes

☐ B.deny

5. How long have you been exposed to BIM technology?[single choice]*

☐ A. More than 5 years

☐ B.3-5 Years

☐ C.1-5 Years

☐ D. Just contact

☐ E.never heard of

6. How many projects did you use BIM technology in?[single choice]*

☐ A. More than 10 projects

☐ B. Of the 5-10 items

☐ C.1-5 Projects

☐ D. Never use

7. Why did you use the BIM technology?[multiple choice]*

☐ A. Can help me to improve my work efficiency

☐ B. Unified requirements within the company

☐ C. Requirements of the project builder

☐ D. Help me to evaluate awards or get a professional title

☐ E. Project budget or time is tight

☐ F. The project construction is very difficult

☐ G. Convenient project management

8. What kind of BIM technology software have you used?[multiple choice]*

☐ A.Revit 、Bentley 、ArchiCAD 、CATIA

☐ B.Onuma Planning System 、 Affinity

☐ C.Rhino 、Tekla 、MagiCAD 、SketchUp 、Civil 3D

☐ D.PKPM 、YJK 、Robot 、STAAD 、ETABS

☐ E.3DSMax 、Artlantis 、Ac-cuRender 、Navisworks 、Lumion

☐ F.Solibri 、Innovaya

☐ G.Autodesk 、Navisworks 、Bentley 、Navigator 、Projectwise 、

☐ H.Autodesk FM Desktop 、ARCHIBUS 、ArchiFM

9. What help do you think BIM technology can provide for architectural design?[multiple choice]*

☐ A.3-dimensional visualization for easy inspection

☐ B. Parameter modelling, to help with the modification

☐ C. Collaborative design to improve efficiency

☐ D. Simulation and analysis, and optimized the design

☐ E. Cost estimation, to facilitate cost saving and energy saving

10. What help do you think BIM technology can provide for building construction?[multiple choice]*

☐ A. Real-time communication is realized based on the BIM model

☐ B. Quick check of errors and errors in the BIM model

☐ C. Assist in the construction of deepening design or deepening drawings

☐ D. Provide detailed model processes and drawings for manufacturing and assembly

☐ E. Help the construction analysis and planning, and improve the construction quality

11. What do you think needs the support for the promotion of BIM technology?[multiple choice]*

☐ A.technical support

☐ B.policy support

☐ C.financial support

☐ D. Talent support

☐ E.indeterminacy

12. What problems do you think need to be solved in the promotion process of BIM technology?[multiple choice]*

☐ A. Technical standards are not uniform

☐ B. Lack of talent

☐ C. Lack of corporate awareness

☐ D. The cost is too high

☐ E. Technology application software is not mature

☐ F.indeterminacy

PART C

The application prospect and significance of BIM technology in architecture (this part is a scale question, 1-5 points, the higher the score, the higher the willingness or recognition)

13. How much do you like to learn BIM technology?[single choice]*

☐ A.1

☐ B.2

☐ C.3

☐ D.4

☐ E.5

14. How convenient and mature is the relevant software operation when you actually use BIM technology?[single choice]*

☐ A.1

☐ B.2

☐ C.3

☐ D.4

☐ E.5

15. How effective can BIM technology do when you work effectively with BIM technology?[single choice]*

☐ A.1

☐ B.2

☐ C.3

☐ D.4

☐ E.5

16. How much do you think BIM technology can help you to reduce costs in enterprise management?[single choice]*

☐ A.1

☐ B.2

☐ C.3

☐ D.4

☐ E.5

17. How much help do you think BIM technology can bring about to improve management efficiency in project management?[single choice]*

☐ A.1

☐ B.2

☐ C.3

☐ D.4

☐ E.5

18. How much do you think BIM technology can help you to improve the design efficiency in the architectural project design?[single choice]*

☐ A.1

☐ B.2

☐ C.3

☐ D.4

☐ E.5

19., How much help do you think that BIM technology can bring to the construction site analysis and on-site communication and coordination in the construction of construction projects?[single choice]*

☐ A.1

☐ B.2

☐ C.3

☐ D.4

☐ E.5

20. How do you think it is to learn BIM technology?[single choice]*

☐ A.1

☐ B.2

☐ C.3

☐ D.4

☐ E.5

21. At present, BIM software is developed by foreign countries. How are you willing to develop BIM technology software in China?[single choice]*

☐ A.1

☐ B.2

☐ C.3

☐ D.4

☐ E.5

22. How likely do you think that BIM technology will become the mainstream technology in the construction industry in the future?[single choice]*

☐ A.1

☐ B.2

☐ C.3

☐ D.4

☐ E.5

23. Do you think the promotion of BIM technology is of great significance to the sustainable development of the construction industry?[single choice]*

☐ A.1

☐ B.2

☐ C.3

☐ D.4

☐ E.5

VITA

NAME	Zijing LIU