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A Study on Chinese Smart Construction Strategy by SWOT Analysis

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ABSTRACT: Nowadays, BIM(Building Information Modeling) technology has been slowly accepted and developed around the world, making smart construction possible. Many countries are also actively promoting the comprehensive application of BIM and changing the traditional construction methods of the construction industry. This study reviews foreign and domestic literature reviews on BIM application barriers and smart construction applications, providing a theoretical basis for Chinese construction enterprises to reduce or eliminate BIM application barriers. Based on the common feature of policies or strategies that promote the development of smart construction in developed countries, such as the United States, the United Kingdom, and Singapore, the deficiencies of China's smart construction policies for construction enterprises are analyzed. Moreover, according to the literature review of the development status of China's construction industry, the SWOT analysis matrix of China's smart construction strategy is obtained. Finally, based on the SWOT matrix analysis results, combined with the development status of China's construction industry and the obstacles faced by smart construction, the portfolio strategies and recommendations for the development of smart construction are proposed in this work. These portfolio strategies and recommendations can provide a reference value for construction enterprises.

KEYWORDS: Smart Construction, BIM, SWOT, Portfolio Strategies

키 워 드: 스마트건설, BIM, SWOT, 포트폴리오전략

1. Introduction

As a key technology for implementing smart construction, BIM(Building Information Modeling) has direct or indirect economic and commercial value to the construction industry. According to data reported by HM Government (2015), implementing BIM helped save 20% of capital expenditures and construction costs of up to 804 million pounds.

The enormous economic value of BIM is widely recognized and accepted on a global scale. According to Bryden Wood's assessment of infrastructure performance, smart construction is not widely used, but it offers the best opportunity to increase productivity. The construction industry, which is generally regarded as a traditional industry that is mainly labor–intensive, has also been constantly criticized for its low efficiency, fragmentation, and slow innovation, with two–thirds of contractors having no innovation at all (Designing Buildings Wiki, 2017). After analyzing the digitization level of China, the United States and Europe by the same index, McKinsey(2017)points out that among the major industries, the digitization level of the construction industry is the lowest. While digitization and informatization are changing other industries, the construction industry still maintains the traditional extensive construction mode, failing to keep pace

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with the pace of the fourth industrial revolution.

China's construction industry accounts for 6.66% of the national economy, playing an important role in promoting China's economic growth and all-round social development (Cheng et al., 2015). Although the country has vigorously promoted the application of BIM in recent years to promote the development of information technology in the construction industry, there are many application obstacles at the three levels of technology, organization, and environment, which make the informatization process of the construction industry relatively slow. Furthermore, the management level of most construction enterprises is relatively low and there is still no institutionalized and standardized management mode.

Therefore, smart construction must meet the high level of BIM and multi-dimensional application requirements to achieve its great commercial value. Hence, whether in the process of implementing the smart construction strategy from the national level or the construction enterprise level, the primary problem to be solved is to eliminate the application obstacles and obstacles of BIM in the construction industry. For example, the lack of BIM standards and guidelines, BIM talents, immaturity of BIM software and so on, these factors are mainly divided into business environment and human behavior.

The goal of this paper is to provide reference value for Chinese construction enterprises to implement smart construction strategies. In order to reduce or eliminate the obstacles and obstacles of BIM application, this work proposes portfolio strategies of smart construction. From the perspective of Chinese construction enterprises, the portfolio strategy mainly includes three relationships, competition and cooperation, technology and talent, as well as domestic and foreign markets.

The structure of the paper is as follows. Section 2 presents an overview of related works obstacles to BIM applications. Section 3 introduces the advantages, weaknesses, opportunities, and threats of China's construction industry development and draws the SWOT analysis matrix of the smart construction strategy in Chinese construction. Section 4 proposes a portfolio strategy for the smart construction and development of Chinese construction enterprise. Finally, concludes the paper and further development plans.

2. Related works

2.1 Bottlenecks and obstacles to BIM applications

China's BIM technology is still at an early stage of development. Construction enterprises often face many problems during the construction of the project. It mainly includes the phenomenon of "information island", the cost of design change increases and the risk of rework (Wang, 2013; Zhang, 2016). The main causes of these problems include organizational factors, industry factors, economic factors, and policy factors.

Construction sites often cause accidents due to lack of communication and can lead to many serious on-site problems and delays in project progress (Kochovski and Stankovski, 2018). According to the results of Liu et al. (2018), the development of smart construction has been limited by the controversial relationship between system developers and industry users. Although BIM applications have gradually been accepted by the industry as a core technology for smart construction in recent years, according to the results of Xue et al. (2010), collaborative work is still affected by two key factors: the business environment and human behavior.

This paper makes a preliminary review of domestic and foreign literature in recent years. It is obvious that the problem is that Chinese construction enterprises are negative in their attitude towards implementing smart construction and BIM because of the obstacles and implementation risks of BIM. Hence, how to eliminate the concerns of Chinese construction enterprises to implement smart construction has become the most urgent issue at present. The following literature review will reveal these concerns.

At present, the main obstacle to promoting the development of information technology in the construction industry is that the application level of BIM is limited. He and Zhang (2012)pointed out that the main factors affecting the application of BIM in the construction industry include owner requirements, government requirements, compatibility of BIM software and application cost of BIM. Liu et al.(2012)believe that the immaturity of BIM software, the lack of BIM application cases and high hardware requirements are the main reasons influencing BIM application. Zhang et al. (2013) believe that the obstacles to the application of BIM are the lack of BIM contracts and laws, BIM standards and guidelines,

government publicity and guidance, cooperation among all participants, little BIM practical experience, lack of BIM talents, unaccustomed to changes in thinking mode, unclear BIM returns and high initial investment in BIM hardware and software.

Azhar (2011) believes that the main obstacles to the implementation and application of BIM are unclear ways of implementation and use of BIM, unclear ownership of BIM data, lack of BIM standards and process guidelines, and unclear subjects of construction of models and costs. In the opinion of Eastman et al. (2011), the main obstacle of BIM implementation is that employees abandon old thinking habits, work processes and lack of trained BIM personnel. According to Migilinskas et al. (2013) software incompatibility, long use time, high cost, unclear application model of BIM, high initial investment, long learning software, insufficient high-level support, and lack of BIM standards and guidelines are the main factors hindering the use of BIM in the construction industry.

From the practice of smart construction, some researchers have done relevant research to eliminate the obstacles of BIM application. These studies focus on collaborative work applications and lean construction throughout the life cycle. Such as cloud management platform, smart construction support system, smart cost management, smart construction site, and mobile applications.

Guerriero et al. (2017) demonstrated through action research that the building information model is a key method for achieving project work flow collaboration, described the collaborative relationship between the smart construction planner and BIM, which were used to implement lean construction.

Moreover, in order to achieve high-efficiency collaboration, some researchers have proposed using visual models to achieve collaborative work on the construction site. For example, Platform's architecture of cloud computing is proposed by Liu et al. (2016) that based on the construction site, Wireless Sensor Network and cloud computing to establish the fusion of the real world and digital world, in order to realize the perception of people and objects, control and intelligent service. Kim et al. (2017) analyzed the development trend of mobile applications and developed a mobile application that can be used in both Android and IOS environments to improve construction site management efficiency. The development of the mobile application is based on high-speed network to realize real-time communication of information.

As shown in Table 1, based on the summary of the obstacles in the literature above, the application risk of BIM mainly includes seven aspects. Among them, policy, industry, law and economy belong to business environment factors, community, technology and talent belong to human behavior factors and they influence and promote each other.

Table 1. Obstacles to BIM application

Obstacles	Factor	Factor
Business Environment	Policy	The government requires
		Lack of BIM standards and process guidance
	Industry	The owner needs
		BIM model quality
		Lack of BIM application cases
	Law	Lack of BIM contracts and laws
		Ownership of BIM data is unclear
	Economic	High demand hardware configuration
		Unclear BIM gains
Human Behavior	Community	Lack of collaboration
		Non-uniform specifications and data
	Technique	Compatibility of BIM software
		Immature BIM software
	Talent	Changes in thinking patterns
		Lack of BIM talent

2.2 Smart construction policy in China

Developed countries have relatively mature experience in promoting BIM development as shown in Table 2. The common points of promoting smart construction strategies mainly include five aspects.

Table 2. Common feature of developed countries

Point	Description	Policy/Contents
Common Feature	Adhere to the government's leadership	GSA; Cabinet Office,BSI; BCA
	Implementation strategy priorities	PBS series plan; GCS2011, GCS2016; BIM Roadmap 2010, BIM Roadmap 2015
	Promote demonstration projects	Establish 10 projects; Promote BIM's successful application cases
	Industry-university research cooperation	established research cooperation projects
	Strengthen international cooperation	USA, Finland, Denmark, Norway

(GSA; BSI; Cabinet Office; BCA)

Table 3. Smart construction policy of China

State Organs	Year	Strategic Policy	Strategic Priorities
State Council	2013.02	State Council's Guiding Opinions on Promoting the Orderly and Healthy Development of Internet of Things	Internet of Things
	2015.05	Made in China 2025	Big Data
	2015.05	Internet + artificial intelligence three years implementation plan	Enforcing green manufacturing Integrating information technology and industry
	2015.08	Action Plan for Big Data Development	Artificial intelligence
	2016.07	13th Five-Year Plan_National Science and Technology Innovation Plan	Innovation Informatization
	2016.12	13th Five-Year Plan_National Informatization Plan	
MOHURD	2011.05	Construction industry informatization development outline from 2011 to 2015	Construction industry informatization Building information model
	2015.06	Guidance on advancing the application of building information modeling	
	2016.08	Construction industry informatization development outline from 2016 to 2020	
	2016.12	Unified standard for building information modeling	BIM National Standard
	2017.05	Standard for building information modeling in construction	
	2017.10	Standard for classification and coding of building information model	

(The State Council of the People's Republic of China; Ministry of Housing and Urban-Rural Development of China)

First, Governments have successively introduced the implementation steps of BIM in specific timetables and played a coordinating role with the realization of the planning objectives. Such as the USA's GSA(General Services Administration), UK's Cabinet Office and BSI(British Standards Institution), and Singapore's BCA(Building and Construction Authority).

Second, in order to promote the application of BIM technology, a BIM technology implementation strategy at the national level has been formulated. On this basis, BIM guidelines suitable for the country or region are formulated to guide the implementation of BIM in the industry. Such as the USA PBS series plan, UK GCS 2011, GCS 2016, and Singapore's BIM Roadmap 2010 and BIM Roadmap 2015.

Third, enforcing the promotion of BIM applications in public buildings through government power is an internationally accepted practice. Due to the special nature of the government or investment public buildings, the demonstration projects facilitate government coordination and control. With the increase of practical experience, technical standards and government policies are further improved, gradually transition to guiding the use of BIM in non-governmental construction projects. Establish 10 projects to test the expected effect and feasibility of BIM and reduce the obstacles to BIM implementation in USA. Promote BIM's successful application cases and remove barriers that may affect BIM applications in Singapore.

Fourth, actively carrying out industry-university research is an important means of guaranteeing the implementation of BIM. For example, the USA government maintains cooperation and communication with industry, standards committees, and academic institutions. Singapore has established research cooperation projects with two universities.

Finally, international communication and cooperation are conducive to the unification of BIM application standards and data format, as well as an important way to guarantee the cooperation of BIM in international projects. GSA cooperation with Senate Properties (Finland), Danish Enterprise and Construction Authority (Denmark), Directorate of Public Construction and Property (Norway), in order to promote the different software data can be exchanged (GSA, 2008).

Compared with the United States, the United Kingdom, and Singapore, China's smart construction is still in the exploration stage. China's construction industry has problems of labor intensiveness, low productivity,

Table 4. SWOT analysis matrix of the Chinese smart construction

Object	Criteria		Description
Chinese smart construction	S	S1	Smart construction has a wide application environment.
		S2	The comparative advantage of labor and management costs helps to improve the competitiveness of enterprises.
		S3	BIM in smart construction sites provides a reference for the implementation of smart construction.
	W	W1	Construction enterprises have high asset-liability ratio and insufficient profitability.
		W2	The development of smart construction faces the bottleneck of lack of talent.
		W3	Construction enterprises lack BIM implementation standards and guidelines.
	O	O1	Smart construction complied with the needs of the transformation and upgrading of the construction industry.
		O2	BIM technology has a promising application prospect for smart construction market segmentation.
		O3	Fusion application technology of BIM and smart construction.
	T	T1	Technical talents attract and retain problems.
		T2	The application obstruction of BIM leads to the uncertainty of benefit in smart construction.
		T3	Smart construction lacks supporting industrial chain.

construction risks and quality problems, and low management levels of construction enterprise. Because the lower of BIM application level, there is still a certain gap with the degree of international informatization. Hence, the government has issued a series of policies on promoting the development of smart construction (See Table 3). During the 12th Five–Year Plan period (2011–2015), smart construction was mainly based on the government leading national policy. It can be seen from Table 3 that during the 13th Five–Year Plan period, China accelerated the development process of promoting the informatization of the construction industry and successively announced the standards and plans at the national level.

From the perspective of national policies, the BIM standard at the national level has been released and has begun to promote the integration of BIM and big data, artificial intelligence, Internet+, internet of things and other technologies. In spite of this, compared to the United States, the United Kingdom and Singapore, China currently lacks BIM standards, policies and application guidelines. These barriers will be explained below based on a literature review.

Wang et al. (2012) found through surveys that construction enterprises are cautious in the application of BIM, even those that adopt BIM have lower application levels. Ji et al. (2014) found that the application of BIM was hindered due to the externality. The externality is mainly hampered by the business environment, which makes BIM unable to realize its value benefits. Wang et al. (2014) and Li et al. (2016) studied the application problems of BIM in the construction stage and explained that the BIM software standard, BIM model quality, lack of collaboration, specification, data inconsistency and the lack of BIM awareness. These are the obstacles and risks leading to the BIM application in the construction stage.

Moreover, some scholars have studied the risk factors of BIM applications from different perspectives. From the perspective of the TAM(Technology Acceptance Model), the policy environment is the decisive factor influencing enterprises (Xu and Zhu, 2015). From the perspective of construction cost process, application environment, technical standards, and organization management are risk factors for the implementation of BIM application (Liu and Guo, 2016). From the perspective of hierarchical analysis, Qie et al. (2016) pointed out that technology, regulations, and organizational management are the main risk factors for shadow construction enterprises to apply BIM.

3. SWOT qualitative analysis of Chinese construction industry

According to Section 2, BIM has application barriers and risks in the construction industry. Therefore, in this section, based on the literature review of China's smart construction, from the relationship between smart construction sites, smart buildings, and BIM technology, the qualitative analysis results of China's smart construction of SWOT are summarized as shown in Table 4. The results are intended to eliminate the application barriers of smart construction, and ultimately provide the basis for portfolio strategy of construction enterprise.

3.1 Strengths

In recent years, China has achieved success in major engineering construction. The comparative advantage of labor and management costs further enhances the international level and international competitiveness of construction enterprises (Song et al., 2010). With the deepening of reform and opening up, the construction industry market has grown rapidly (Gu et al., 2012). According to the ENR's 2017 Top 250 Global Contractors, the number of Chinese construction enterprises reached 65 contractors, of which the top five are all Chinese enterprises.

At present, China construction enterprises are facing upward pressure on labor costs, which could force enterprises to increase their growth through other means. Overall, the long-term upward trend in labor costs will drive companies to support future growth through technological innovation. Cheng et al. (2016) also verified by positive analysis that technological innovation has a substitution effect in the causal relationship between rising labor costs and promoting enterprise growth.

As shown in Figure 1, the application of smart construction site in construction projects reaches 50%. With the continuous maturity of BIM technology and the decrease of application cost, the probability of construction enterprises to adopt smart construction sites will further improve. Smart construction sites based on BIM technology are also widely used in construction planning and schedule management.

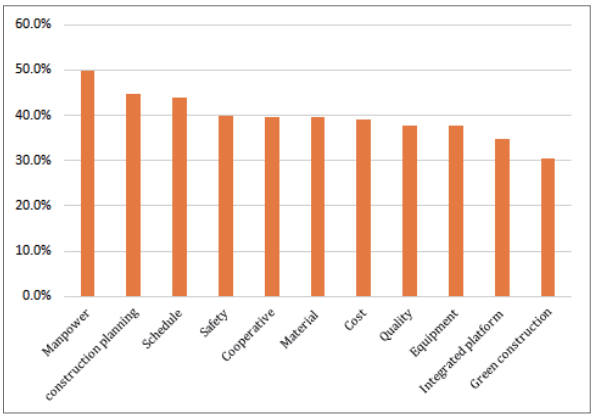

Figure 1. Application fields of smart construction sites (Report on the development of construction industry 2017)

3.2 Weaknesses

Smart construction is supported and developed in China, but it must also face and solve the following problems. As shown in Figure 2, their asset-liability ratio is already higher than the average level.

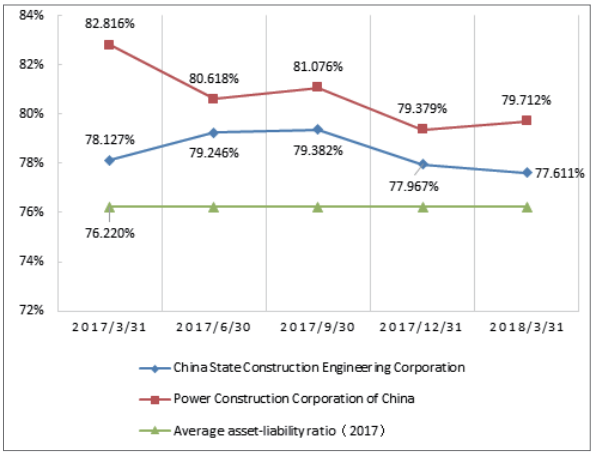

Figure 2. China construction enterprise asset-liability ratio (SINA Corporation and wind, 2017/03 - 2018/03)

Affected by the construction industry scale, production capacity, production efficiency, and technical equipment level, China's regional development of construction industry is uneven. From the eastern coastal areas to the western inland areas, the development of the transition from fast to slow and the coupling relationship with regional economic development is obvious (Yang et al., 2017).

The development of Chinese construction enterprises relies heavily on social fixed asset investment, with high asset-liability ratio and insufficient profitability (Gu et al.,

Table 5. Asset–liability ratio ranking by industry (China)

No.	Industry	Debt Asset Ratio (%)
1	Financial	91.59
2	Real estate	78.85
3	Construction	76.22
4	Public career	64.84
5	Household appliance	62.99
6	Steel	61.29
7	Delivery equipment	58.48
8	Non-ferrous metal	56.47
9	Electrical equipment	55.81
10	Communication & transportation	55.8

(Choice data, 2017)

2012). This will limit the investment of construction enterprise in smart construction talent training and technology research, thereby reduce the confidence of enterprises in smart construction.

As shown in Table 5, in the top ten industry rankings of China's asset–liability ratio in 2017, the construction industry ranked third with an average of 76.22%. Nevertheless, due to the lack of construction and management capabilities of the construction enterprises, coupled with the vicious competition in the market, the weak cooperation of the participants and the external factors such as the difficulty of the claims, the profitability of the construction enterprises is low (Bai, 2012).

In addition, although the country has issued BIM–related standards, construction companies are still in the exploration stage for smart construction and there are no specific implementation standards and related guidelines. Moreover, the development of smart construction is seriously lacking professional talents and research talents. In the implementation stage of smart construction, there are many systems and the integration is difficult. As the level of internationalization of construction enterprises continues to increase, it is facing the bottleneck of lack of senior talents with international management experience (Wang and Li, 2017).

3.3 Opportunities

The fourth industrial revolution created opportunities for the development of smart construction. First, the integration of BIM technology has enabled digital construction and innovation to drive the development needs of the transformation and upgrading of the construction industry. In the future, green low carbon will become a new growth point for the industry (EY, 2016). Second, rapid urbanization and emerging smart cities have become potential infrastructure development opportunities in the industry.

The rise of low–carbon construction concepts, such as green economy and green buildings, has created conditions for the implementation of smart construction. This makes BIM's application prospects for the future of segmentation construction market very impressive. Such as BIM and smart buildings, BIM and green buildings, and BIM and prefabricated buildings.

At present, China actively promotes the construction of information technology and introduces relevant policies and standards (see Table 3), promotes the application of BIM and opens the prelude to smart construction. The government actively guides enterprises to adopt smart construction and promote multi–dimensional development and application of BIM technology. Such as BIM and IoT(Internet of Things), BIM and Big Data, and BIM and AI(Artificial Intelligence).

3.4 Threats

Nowadays, factors such as insufficient talent resources, lack of high–quality talents and frequent staff turnover restrict the application level of BIM. Besides, the professional advantages of construction enterprises in developed countries have intensified the competitive pressure of Chinese construction enterprises in the international arena (Shen, 2012).

While China's construction market continues to grow in size, it also faces many threats. The obstacles and bottlenecks of BIM application make the construction enterprise concerned about the uncertainty of earnings for the implementation of intelligent construction. Such as high input, low return risk and the risk of brain drain.

Furthermore, construction enterprises face great pressure to promote smart construction. For example, the enterprise does not establish BIM certification system architecture

and smart construction implementation rules and lacks implementation standards and guidelines.

Due to the large number of participants involved in construction projects, there is a lack of smart construction of supporting industrial chain. The main technology of smart construction is the fusion of BIM and the smart building would realize through smart construction site. This requires smart construction from the early design, construction, procurement, operation and maintenance integration.

4. Strategies for Chinese smart construction

This section will focus on the business environment and human behavior to provide Chinese construction enterprises with portfolio strategy and recommendations. The portfolio strategy includes three relations: competition and cooperation, talent and technology and the overseas market and the domestic market. The portfolio strategies based on the SWOT matrix analysis results, which can help construction enterprises to eliminate obstacles and risk factors for implementing smart construction and provide a reference value for construction enterprises.

4.1 SO Strategy

SO is a strong core strategy for enterprises. As we all know, technology is the key to leading the development of enterprises and smart construction technology can inject new impetus into the development of enterprises. Construction enterprises should establish successful case of BIM construction on smart construction sites and constantly improve the smart construction management system.

Compared with developed countries, China's construction industry is still relatively backward in the level of smart construction. Therefore, the implementation of the diversified strategy is an important way for Chinese construction enterprises to go international. Chinese construction enterprises build corporate brands through overseas construction projects and improve their own construction standards and management levels through the overseas construction market. Through brand strategy as the leading strategy to improve the competitiveness of enterprises in the international market, differentiate strategies to improve corporate profits and centralized strategies to improve the quality of corporate services.

The rise of foreign emerging construction market is an opportunity for Chinese construction enterprises to improve the level of internationalization. There is still a big gap between Chinese construction enterprises' internationalization level and that of developed economies. Therefore, based on the domestic market, we need to expand the overseas market. Meanwhile, large enterprises should take national policies as a guide to promote the integration of BIM technical standards with international standards. Through cooperation with foreign software development companies with mature application level of BIM, the implementation standards and application level of Chinese construction enterprises are constantly improved. Seize the opportunity of national transformation and upgrading of the construction industry and promote innovation of green and low-carbon construction technology. SMEs(Small and medium-sized enterprises) participate in the international construction market competition through cooperation with large enterprises. Cooperation methods include but are not limited to the provision of differentiated services and management methods, as well as the dispatch of skilled talents and targeted cooperation in smart construction solutions.

4.2 ST Strategy

As a diversified strategy, ST is the main strategy for enterprises to share business risks and improve their profitability. Construction enterprises should full use of their comparative advantages and expand overseas markets though their rich construction experience to participate in international competition. Moreover, enhance the theoretical and technological innovation of smart construction and internal evaluation and application standards should be established. As the key technology of smart construction, enterprise should establish BIM standards of enterprises under the guidance of national standards. For promote technical innovation through standards to solve the problems faced by the application of enterprise standards at different levels.

Construction enterprises should improve the talent reserve mechanism because talent will be the main production factor

for the industry to realize smart construction. At present, however, the lack of professional technical talents in China's construction market is the main problem that Chinese construction enterprises face in improving their management level. The United States and Singapore have implemented industry–university–research plan for the talent pool, as well as hierarchical training plan and the UK motivates young workers by improving the image of the industry.

As smart construction is an emerging construction theory and still developing and improving. This is also an opportunity for Chinese construction enterprises to develop at the same level as foreign companies. Therefore, promoting the multi–dimensional application of its core technology BIM and building benchmarking cases are important tasks in implementing brand strategy and participating in international competition. Efforts to improve the supporting industrial chain of smart construction are the main tasks for enterprises to improve their core competitiveness and achieve profit diversification.

4.3 WO Strategy

As a reversal strategy, WO is a strategy for enterprises to use their development opportunities to enhance their own competitiveness. BIM is the key technology to promote the development of smart construction. Implementing BIM solutions and transforming management methods can improve project profitability.

Enterprises could improve the company's support system for BIM software standards and data formats in overseas markets by working with software companies based on BIM integrated software application standards and successful application examples in the domestic market. Develop an organizational and management model that is commensurate with the smart construction system and optimize the project management process.

Actively develop an IPD(Integrated Project Delivery) model, improve BIM international standard contracts and expand overseas markets. The key to the current BIM application of construction enterprises is the lack of management and practice. Since there is no clear ownership of BIM data, it affects the level of collaboration among all participants in the project. The IPD model is a new integrated delivery method for construction projects based on BIM technology. The information sharing of projects through BIM technology and the efficient collaboration of different professional teams have greatly promoted the integration of project members and the application of BIM. It is a change in the traditional project management model.

4.4 WT Strategy

The improvement of employee retention rate is of great significance to construction enterprises. On the one hand, construction enterprise should establish the employee culture system of the enterprise to improve the organizational identification and job satisfaction of employees. On the other hand, establish a reasonable employee welfare system, such as salary system, vocational training and development, and job promotion system. Provide employees with job security and fulfill the organizational commitment to employees.

Additionally, enterprise could actively explore the PPP(Public–Private Partnership) construction model. PPP is not only a new construction mode but also a new financing model. It can promote the diversification of investment entities to lower the threshold for SMEs to enter the market competition, also better weaken risks. Finally, SMEs can use the internet and cloud platforms to expand financing channels. Such as crowd funding, P2P and other network financing models. Although the current network financing risk is relatively large, with the continuous improvement of the government's supervision system of network financing, it can help enterprises solve financing problems within the visible expectations.

5. Conclusions

Smart construction complies with the development trend of building information and is complementary to BIM, which would promote the development of building information. By reviewing the literature review that hinders the development of smart construction and the current situation of China's construction industry, this paper draws the SWOT analysis matrix of China's smart construction. Based on the results of the analysis matrix and with reference to the relatively mature strategies of the United States, the United Kingdom and Singapore, this paper proposes portfolio strategy for

Chinese construction enterprises. The portfolio strategies aim to reduce and eliminate the commercial environmental risks and human behavioral factors that hinder the application of smart construction, providing reference significance for Chinese construction enterprises to implement smart construction. Its main content is summarized as follows.

1) Technology and cooperation strategy. This strategy is a growth strategy for the company, which aims to give full play to the benefits of technology and cooperation to enable the company to develop. Through cooperation, learn the construction technology of foreign construction enterprise, thereby improving the application level and international competitiveness of Chinese enterprises' smart construction. On the contrary, the improvement of corporate competitiveness can provide more cooperation opportunities for enterprises.

2) Competition and talent strategy. This strategy is to provide enterprises with a diversified strategy to weaken the risks they face and improve their ability to deal with the crisis. Such as brand strategy, talent reserve strategy, and industry–university–research cooperation strategy. Moreover, the enterprise improves employee organizational identification and job satisfaction by building a corporate employee culture system and improving employee career promotion standards.

3) Two market strategy. This strategy captures development opportunities on the premise that enterprise avoid unfavorable factors. The strategy mainly includes improving the application standards of the company's own BIM and the support system for BIM international standards. Actively explore the IPD model to transform the traditional management model.

4) Risk aversion strategy. This strategy mainly solves the financing problem of SMEs and improve talent retention rate. It provides references for enterprises to solve financing problems from three aspects, reforming supply chain mode, PPP construction mode and internet financing.

This paper proposes relevant strategies and implementation suggestions of smart construction from the perspective of construction enterprises. However, the fusion of smart construction and BIM multi–dimensional technologies also requires to implement continuous policy guidance at the national level to promote and develop. Therefore, the subsequent research will focus on the development and improvement of smart construction implementation strategies and action plans at the national level.

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