

Review and Prospect of BIM Policy in China

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Abstract. In the process of architectural design, construction, operation and maintenance, the problem of inefficiency and inaccuracy in information application and exchange has caused substantial waste of resources and risk in construction industry. Building Information Management provides an opportunity to address the issue. Building information modelling (BIM) has been increasingly applied in design, construction and other information management in China as its important role in reducing engineering changes, improving engineering quality, shortening project duration, saving project cost, enhancing information sharing among the participants many others. As an integration of process and product, its development and implementation need government regulation to enhance its applications effect and standardize its adoption and implementation. Especially, the government guidance affects the application and development of new technology to a great extent in China. However, relevant policy development falls behind the rapid development of its application in practice in China, which has led to many problems in construction practice. In order to develop effective BIM policy for China, this paper conducted a comprehensive review about existing BIM policy in China by analysing its status and problems, comparing it with the corresponding policy in developed countries such as the USA and UK. The expected policy development direction is also discussed and proposed.

1. Introduction

According to the definition of National BIM Standard-United States®, building information modelling (BIM) is a digital representation of physical and functional characteristics of a facility. As such, it serves as a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its life cycle from inception onward [1]. By using BIM as an information warehouse, all parties of the construction can have a better visualization and communication, which can help increase their collaboration and coordination throughout the design stage, predict and control the construction process to a great extent, reduce time and cost in construction processes, and enhance management of assets and facilities throughout the building's life cycle [2]. Due to its strong advantage in information-sharing and potential benefits in generating process and performance improvement in the construction industry [3, 4], it has been increasingly recognized in the construction industry. Its appearance has changed the traditional management mode in construction field and led to great technological innovation in this field.

Although BIM was proposed in the 70th of last century, BIM technology developed quickly in the last decade. However, there are still many problems need to be solved, like human resource problem,



cost problem, management problem, law problem and technology problem [5]. Therefore, its development and application needs government regulation to enhance its applications effect and standardize its application. Especially, the government orientation affects the application and development of new technology to a great extent in China. However, in China, relevant policy development can't keep up with the rapid requirement of BIM application in practice, which has restricted its application and development in construction practice. To figure out its status and problems is significant for its wide application and sound development in China's construction industry. Based on this, we propose some expected BIM policy development direction in China.

2. Status and problems of BIM policy in China

The informatisation development period of construction industry is not very long in China. BIM technology had a great development in China in the recognition and support of the government in recent years. Nowadays, BIM technology has attracted much attention in the whole construction industry.

2.1. BIM application in China

In United State or many European countries, the number of projects using BIM has exceeded traditional projects [6]. In China, BIM application started relatively late. Fortunately, various BIM consulting firms, training agencies, government departments and guilds pay more attention on the value and significance of BIM application. National forum of information development technology, BIM theme seminar, BIM building design competition, BIM senior training class, and so on, have been held successfully. CCDI, Shanghai Xian Dai Architectural Design (Group), Kling Stubbins International Architectural Design Chinese Division and Aedis Architectural Design and Planning China Company employed BIM technology in different projects to different extent. Meanwhile, encouraged by government's support and promotion, owners' awareness on BIM is also rising.

Nowadays, BIM is relatively adopted more in design units and less in construction units in China [7]. In face of BIM application trends, although some of the domestic enterprises actively attempt it, most of these attempts are local and tentative. Some companies adopted BIM in order to satisfy policy requirement or improve their competitiveness and added value of their design service. Considering depth and breadth, BIM application in China is at its initial stage. In future, it will gradually progress and dive into all areas of the construction industry.

2.2. BIM policy in China

Informatisation is the development trend of the construction industry. China government has also given strong support by providing policy. Among the issued policies, some are policy requirements for BIM technology promoting, some are specific project objectives, and others are guidance advice on BIM application in whole construction process from the technical level.

From 2001, China began its exploration on informatisation. In 2001, the Ministry of Construction (the predecessor of Ministry of Housing and Urban-Rural Development, MOHURD) proposed *Basic Points of Informatisation Work in Construction Field*, which means that informatisation work in construction field is formally launched. In 2003, the Ministry of Construction published *Outline of the Informatisation Development Plan of National Construction Industry (2003-2008)*. It emphasized on implementing of integrated design and intelligent design technology based on engineering database and model design, establishing and improving engineering design system, and implementing collaborative design. In 2010, BIM was listed as the key application technology of informatisation in "Ten new technologies of construction industry".

In 2011, MOHURD issued *Outline of Development of Construction Industry Informatisation (2011-2015)*. It emphasized that we should take BIM as the core support technology, which support industrial upgrading and speed up its application in engineering. In the *Outline*, BIM has been mentioned 9 times, 3 as developmental goal and 6 as developmental key. Meanwhile, the Ministry of Science and Technology (MOST) clearly announced BIM technology as a national key research and application project in "*12th Five-Year Science and Technology Development Planning*". For that reason, the year

2011 was described as "The First Year of China's BIM". In July 2014, MOHURD published *Some opinions on promoting the development and reform of the construction industry*, which refers to the application of BIM and other information technology in the whole process of engineering design, construction and operation and maintenance. In addition, *Evaluation standard for green building* (2014) requires employing BIM in green building design. In June 2015, MOHURD issued *Guidance on Building Information Model Application*. According to the guidance, by the end of 2020, class A reconnaissance and design unit, premium and class A building construction enterprise should master and realize BIM's integrated application with enterprise management system and other information technologies; project ratio of integrated application with BIM reaches 90% in survey design, construction, operation and maintenance of new projects which are large and medium - sized buildings with state - owned capital investment, public buildings which declare green building or green ecological demonstration area. Shanghai, Zhejiang, Guangdong, Liaoning, Shandong Province also issued their BIM application policy. Furthermore, there are some bonus policies. For example, policy regulate that project which employs BIM can get extra points when it declares outstanding engineering survey and design awards; enterprise and personnel which promote the development, construction, investigation, design of BIM application can get extra points in integrity evaluation. In 2016, MOHURD issued *Outline of Development of Construction Industry Informatisation (2016-2020)*, which proposed that we should comprehensively improve the level of construction information and put force effort on enhancing the integrative applications of information technology like BIM, big data, and so on.

Encouraged and promoted by the above state relevant policy, research and development work of BIM standard for China has achieved some initial achievements. In 2010, Tsinghua University announced *Research Report of Chinese BIM Standard Framework*. In early 2012, MOHURD established five projects of BIM national standard development in China. Among them, the *Deliver Standard of Building Design-Information Modelling* has been submitted and passed examination in March, 2017; the *Standard for Classification and Coding of Building Constructions Design Information Model (draft)* has been issued in 2015; the *Unified Standard for Building Information Model Application* has been authorized in December 2016 and will be enforced in July 1th, 2017; the *Storage Standard of Building Information Model* is in processing; the *Application standard for manufacturing industry design information model (draft)* has been issued in 2016. In 2013, MOHURD approved to edit the sixth standard - *Standard for building information modelling in construction*, which has been issued in form of draft in 2016. Table 1 listed the relevant BIM policy issued by China government. In May 2013, China Institute of Building Standard Design & Research gain recognition by the international authority of organization for BIM standardization – buildingSMART (BSA, an affiliate of American Institute of Building Sciences), and established BSA Chinese division. Its establishment marked China's national BIM standard system successfully integrating into the advanced countries' BIM standards.

2.3. Problems of BIM application in China

BIM will be the next mainstream technology and BIM application environment at the national level is the guide of BIM application for enterprise adoption. Therefore, the government has issued many formal or informal policy documents to regulate and promote its application in China. However, its application environment is not mature enough in national level. Many researchers believed that the existing construction industry system, domestic standard and norm are the barriers that we urgently need to break if we want to promote BIM application and development. Following is some problems about BIM application.

2.3.1 Shallow cognition of BIM and BIM Return on investment Cost-Revenue in construction industry

In traditional design, there are some problems such as large professional coordination workload, high design cost, too much attention on the expression of graphics while less attention on the constructability of design. These problems not only lead to low design work efficiency, but also bring some difficulties to construction or even result in rework. However, in practice, due to the low construction cost of manpower and site, the cost of solutions for these engineering problems caused by the design defects is

relatively low. Because of this, the industry and the market relatively have tolerance to traditional design methods. Meanwhile, the benefits and costs of BIM application have not been well assessed and recognized by the Chinese market. Therefore, although managers have an idea about the advantages of BIM and its development trend to some extent, they still hesitate to employ BIM in practice considering the potential risk and short-term benefit shortage, especially in design enterprises [8]. This is partially because the existing policy does not propagate the effective benefits of BIM application in practice. Only changing enterprise's one-sided concept of BIM, it is possible to carry out a wide range of BIM application in China's construction industry.

Table 1. State issued BIM policy in China

No.	Title	Department	Published Time
1	Outline of Development of Construction Industry Informatisation (2011 – 2015)	MOHURD	2011
2	"12th Five-Year" Science and Technology Development Planning	MOST	2011
3	Some Opinions on Promoting the Development and Reform of the Construction Industry	MOHURD	2014
4	Evaluation Standard for Green Building	MOHURD	2014
5	Guidance on Building Information Model Application	MOHURD	2015
6	Outline of Development of Construction Industry Informatisation (2016 – 2020)	MOHURD	2016
7-1	Deliver Standard of Building Design-Information Modelling	MOHURD	In formulation
7-2	Standard for Classification and Coding of Building Constructions Design Information Modelling	MOHURD	In formulation
7-3	Unified Standard for Building Information Modelling Application	MOHURD	Be authorized in 2016, will be enforced in 2017
7-4	Storage Standard of Building Information Modelling	MOHURD	In formulation
7-5	Application Standard for Manufacturing Industry Design Information Modelling	MOHURD	In formulation
7-6	Standard for Building Information Modelling in Construction	MOHURD	In formulation

2.3.2 Lack of sound technical specifications and data standards

The application of BIM mainly includes three stages: design stage, construction stage, and operation and maintenance stage. Only data in the three stages achieve sharing and interaction, value of BIM technology can be realized. Currently, domestic BIM data exchange standards, BIM application capability evaluation criteria and BIM project implementation process standards are still blank or not perfect, which restricted BIM application in application of design display like two-dimensional drawing and reproduce three-dimensional model, or in original island development of professional software.

Currently, although some provinces have issued local BIM standard, such as *Bureau of Public works of Shenzhen Municipality BIM implementation management standards (2015)*. However, China is still lack of systematic and effective national standards, including data exchange standard, evaluation criteria of BIM application capability, BIM implementation process standard, and so on. Even some standards mentioned in 2.2 are still in formulation. To maximize BIM's advantages, Chinese government must make industry standard that each participant must comply with, develop and adopt uniform data standard. Then, the industry can realize information sharing in the whole process and all aspects, which is also the goal of BIM. In the transition period, the relevant department should publish supporting protocol for these BIM tools [9].

2.3.3 Unclear legal responsibility boundary about BIM application

The ambiguous boundary of BIM-related industry regulations and legal responsibility also hindered BIM application in China's construction industry[10, 11]. Although Chinese government has issued some BIM standards, but these standards are still immature and imperfect. Moreover, BIM contract, BIM law and BIM implementation model is basically in blank in construction industry. For example, the standard and depth of the design diagram is not clearly defined in existing policy. The design enterprise just draws two-dimensional drawings from BIM model based on the traditional two-dimensional drawing standard, in which the actual effect of plot is not good. At the same time, the legal responsibility boundary between designers, contractors and project management departments when employ BIM in construction is not clearly defined. Disputes, claims, insurance, contract and other legal issues due to employ BIM should also be standardized in relevant policy.

2.3.4 Lack of BIM professional

As BIM is a relatively new technology and its application is not wide in Chinese construction industry, not many people are familiar with BIM technology or have applied BIM technology in practice [12]. The scarcity of professional limits BIM application. Seldom existing policy emphasizes on the cultivation of professional.

2.3.5 Cost problem

In order to adapt to BIM design method, construction design enterprise, which is in the industry upstream, must make many adjustments. Moreover, BIM software purchase, hardware update and personnel training will inevitably lead to increased costs. Considering market needs and short-term benefits, design and construction enterprise are unwilling to take this part of the increased costs [13]. Although promoting them to employ BIM in practice, seldom policy has mentioned subsidies or tax preference to these enterprises, which employ BIM. In the view of current government promote efforts, government and industry authorities often only mention the requirements, while not or rarely mention policy support. The status that enterprises need to invest by completely self - financing seriously affect the enthusiasm of enterprises to apply BIM technology.

3. BIM policy in developed countries

BIM applications developed rapidly in developed countries. Government and industry give strong support to its development. Herein, we mainly review some efforts on BIM application of the United States and UK.

3.1. BIM policy of United States

United States started the research on construction informatisation earlier and is one of the pioneering countries for BIM application [14]. Unlike some countries, the US government did not enforce BIM from top to down. There are guidelines and standards but not laws or regulations companies have to follow. The market adopted BIM because companies see the benefits and profits from it. According to New McGraw-Hill Construction Report, BIM adoption expands from 17% in 2007 to over 70% in 2012 [6]. More than half of USA construction companies have attained an advanced or expert BIM level. The

leading level of BIM research and application can't be separated from the policy support [15, 16]. Meanwhile, there are various BIM associations and BIM standards. BIM's sound development in US is inseparable from the efforts of the following institutions: General Services Administration (GSA), United States Army Corps of Engineers (USACE) and BSA.

In 2003, GSA through its Public Building Service (PBS) established the *National 3D-4D-BIM Program*. The program is the first of its kind in the world and commits to establish policy to incrementally adopt 3D, 4D and BIM for all major capital projects, and lead 3D-4D-BIM pilot applications and incentives for current and future capital projects, provide expert support and assessment for ongoing capital projects to incorporate 3D, 4D and BIM technologies. This program also encourage partnership between BIM vendors, professional associations, open standard organizations and academic/research institutions for BIM implementation [14]. In order to fulfil the objectives, GSA launched nine pilot projects to study the implementation of BIM, mandated IFC-based BIM for various building analysis and design, and collaborated with BIM software developers to produce a new GSA BIM guide. As part of the program, GSA published the *BIM Guide Series* that provide guidance and requirements for new project teams, ensuring that GSA projects utilize BIM in the most beneficial, efficient way possible at the time of their inception. In 2006, USACE developed and released *Building Information Modelling: A Road Map for Implementation to Support MILCON Transformation and Civil Works Projects within the U.S. Army Corps of Engineers*. In December 2007, American Institute of Building Sciences (NIBS) issued *National BIM Standard – United States® Version 1 (NBIMS-US™ V1)*, which offered the necessary standard and structure so that through which end-users throughout all facets of the industry can use BIM to efficiently access the information needed to create and operate optimized facilities. In July 2015, BSA issued *NBIMS-US™ V2* in May 2012 and *NBIMS-US™ V3*. By the end of 2008, BSA already owned a series of application standards, such as *Industry Foundation Classes (IFC) Standard NBIMS*. At the state level, the government also published some regulations to promote BIM application in their states. In 2009, Wisconsin became the first state which requires large state public building projects in the state to employ BIM. The Texas Facilities Committee also announced the request for BIM application in design and construction phases for state projects. In 2010, the Ohio government promulgates BIM agreement.

3.2 BIM policy of UK

Compared with most countries, the UK government requires the mandatory use of BIM technology [17]. In May, 2011, Cabinet Office issued *Government Construction Strategy (GCS) (2011-2015)*, in which a whole chapter is about BIM. It specifically announced the Government's commitment that it would require fully collaborative 3D BIM on all centrally procured construction contracts by 2016. The document acknowledged that BIM application is limited by the lack of compatible systems, standards and protocols and difference between customer's requirement and leading designer's requirement. Therefore, the British government focused on setting standards to ensure that all members of the BIM chain can collaboratively work through BIM. AEC (UK) BIM Standard Committee published *AEC (UK) BIM Standard* in November 2009 and version 2.0 in September 2012. To guarantee a successful transition from CAD to BIM, it separately published *AEC (UK) BIM Technology Protocol* and updated versions for Revit, Bentley Product, Autodesk Revit, Graphisoft Archicad, and Nemetschek Vectorworks users to provide additional detail and enhancements for the practical implementation of BIM. These efforts insured that BIM not just stay in theory, but can be applied in practice. In March 2016, Cabinet Office and Infrastructure and Projects Authority issued *Government Construction Strategy (GCS) (2016-2020)*. The principal objectives of GCS 2016-20 include embed and increase the use of digital technology, including BIM Level 2. The BIM Working Group will coordinate departments to embed BIM Level 2 and realize its benefits.

4. Results and discussions

BIM has received a tremendous amount of attention from the academia and industry [10]. Many countries in the world have made great efforts to promote BIM application. USA and UK have published

many detailed standards and protocol to promote the research and application of BIM in their country. Based on reviewing of China's current BIM application dilemma, we found that Chinese BIM policy development is not complete. However, the role of Chinese government is critical in the promotion of BIM application, so we expected Chinese government pay more attention on formulating corresponding policies to improve BIM's development [18]. Based on the review of implementation initiatives for BIM by USA government and current policy problems in China, we propose that the Chinese government should play a more proactive role in regulation the implementation of BIM in construction industry.

4.1. Vigorously promote the concept, meaning and value of BIM, strengthen the recognition of BIM applications

Considering the great challenge of BIM application in China, only the practitioner subjectively agrees with BIM's advantage, and is willing to pay for its superior value, BIM application can achieve smooth implementation. Therefore, the government should firstly set up research projects which focus on the analysis of BIM investment, income and other issues that enterprise concerning most. Reasonable evaluate the long-term benefits and costs of BIM application in engineering in China, and take positive measures to reduce the short-term risk as far as possible. Establish demonstration engineering, strengthen publicity for long-term benefits, and encourage enterprises to actively try BIM on their projects by rewarding policy. Establish relevant policies, including increase or enforce the use of BIM in government investment projects. Meanwhile, encourage researchers and industry experts conscientiously sum up the practical experience of BIM, make deep analysis of the problems and explore solutions. Encourage relevant department to organize BIM seminar and share successful experience and management model of BIM application in engineering projects.

4.2. Strengthen the cultivation of BIM professionals.

NBIMS divided BIM related personnel into three categories: BIM user, BIM standard provider and BIM tool manufacturer. Among which, BIM user (BIM professionals) occupied the largest amount. The government, should provide actively guides and environmental support for BIM professional cultivation, promote the construction of BIM professionals from various aspects, and provide strong support for BIM research, application and innovation. Nowadays, many building-related majors in foreign universities have opened courses on BIM, while seldom in China. Therefore, government should promote university to establish BIM course system for Architecture, Structure, and Construction management specialty so as to facilitate the cultivation of BIM application. Furthermore, add BIM research to postgraduate's research direction and facilitate BIM application research, so as to provide theoretical support for BIM standard editing. For architectural designers working on the front line, open BIM training class for them and adopt a compulsory re-education. At the same time, give the enterprise some preference or subsidy to encourage enterprises to participate in the training. As for the training course, not only should relate to the understanding of collaborative design and application of the BIM software, but also should include the relevant content of project management in construction process, emphasize the necessary of knowledge updating, so as to strengthen the source of their positive transformation. Encourage construction enterprises to increase the training and introduction of BIM application talents and finally building a reasonable BIM talent echelon, including enterprise level, project level and professional level.

4.3. Establish BIM application standard system and application guidelines

The government should actively participate in the formulation of BIM standards MOHURD and other related departments play a very important role in the comprehensive promotion of BIM. In this regard, they should actively participate in the formulation of BIM standard, improve the system and norm of construction industry, and integrate the application of BIM in the overall construction industry. Several actions can help in order to further the existing standards. For example, MOHURD should develop three-dimensional BIM drawing standards and regulate the LOD (Level of Development) of BIM drawing. Besides the standards in formulation, MOHURD should pay more attention on the publication and update of

BIM standards and operational guidelines for different users to provide additional details and enhancements for the practical applications of the BIM standard. On the other hand, the government should streamline BIM developers/vendors and synergize various competing BIM software systems in the market in order to solve the interoperability problem.

4.4. Search, revise and supply the relevant terms of the laws, regulations and model agreements

In view of the current status that BIM related industry rules and legal liability is unclear, it is urgent for the relevant departments to establish laws and regulations related to BIM application and clarify the rights and responsibility of BIM application parties. Under the conditions of market economy with Chinese characteristics, we should give full play to the role of policy making department and line ministry to establish a new norm which is future oriented and embroidered on BIM. This part of work includes, but not limited to, standard of BIM depth, responsibility to protect data integrity, equivalent standard of electronic data and paper medium data, responsibility division method when electronic data losing efficacy, boundaries of legal liability between designer, contractor and the project management department. Sets up a special BIM technical department to establish standards, accept complaints, resolve disputes, and impose economic and administrative penalties on offenders.

4.5. Reform the existing construction industry mechanism.

The organization and process of the construction industry in China is in silos, resulting in low overall efficiency of the industry. However, the industry and the market have long tolerated this low efficiency because most of the architectural design enterprises lack transition power. In fact, the process and organization debris of construction is one of the biggest obstacles to the application of BIM technology. Chinese government should reform the existing construction industry and change the organization and business mode of building production.

5. Conclusions

The features of BIM determine its impact and value on the construction industry will be much extensive and profound than CAD, but also imply that the required effort and possible difficulties to learn and popularize BIM will be bigger than CAD[19]. This study has provided a review on the status and development of BIM policy in China, founded that BIM policy is not perfect in some aspects. Compared to BIM policies of UK and US, this study proposed some suggestion on development direction of policies for BIM implementation in China.

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