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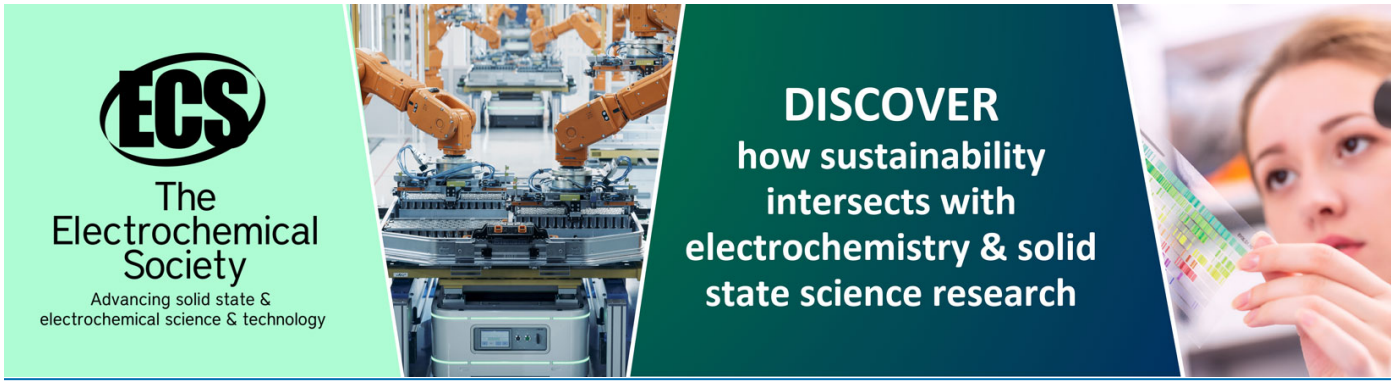

Research on obstacles of BIM Application in Commercial Building Operation and maintenance stage based on Analytic hierarchy process

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Abstract. The COVID-19 's epidemic situation makes the demand of smart city more obvious, and the application of BIM technology will speed up this process. This study takes the obstacles to the application of BIM in the operation and maintenance stage of commercial buildings as the research object, adopts AHP method, constructs the hierarchical relationship of factors, and focuses on the influence and hierarchical relationship of technology, cost, standard, information and other factors on the obstacles of BIM application. The study found that the main factors affecting the application of BIM in the operation and maintenance stage of commercial buildings are application cost and information data. Based on this, this paper puts forward some strategies and suggestions for enterprises to promote the application of BIM technology in the operation and maintenance stage, which provides a reference for promoting the comprehensive and efficient application of BIM in the operation and maintenance stage.

1. Introduction

In recent years, the overall growth trend of China's construction industry has slowed down, the traditional construction model of pursuing high-speed expansion has entered the end of development, and the construction industry is in a critical period of transformation into the stage of high-quality sustainable development. To actively develop BIM technology and improve the informatization level of the construction industry is not only the mandatory requirement of national policies and regulations, but also the only way for economic and social development and the development of the construction industry.

Under the influence of COVID-19 's epidemic situation, the traditional labour-intensive operation and maintenance management has been affected by the inability of personnel to return to work, so the application of BIM in intelligent operation and maintenance management has been paid more attention because of its intelligent management, less space restrictions, clear and accurate operation and maintenance information, and less personnel required.

As the last stage of the building life cycle, the operation and maintenance phase involves long working hours, many contents and complexity, the management is difficult, and the expenditure incurred in the operation and maintenance phase accounts for 75% of the building life cycle, so the application of BIM technology in the building operation and maintenance phase is an important driving force and main direction of BIM application. However, at present, researchers are relatively lack of research on the application of BIM technology in the stage of operation and maintenance.

According to the comprehensive literature research, the academic circles have made an analysis from some aspects that affect the application of BIM technology in the stage of operation and maintenance. However, through the analysis, it is found that there are some shortcomings in the research: first, in terms of content, the academic circles mostly stand in the overall perspective of the whole process of BIM technology construction, and there are no specific obstacles to the application of BIM technology in the stage of operation and maintenance. Second, from the perspective of methods, most of them use qualitative analysis to summarize the factors that affect the application of BIM technology in the operation and maintenance stage, and do not use quantitative research methods to measure the relationship between factors and the importance of various factors. Therefore, it is necessary to reconstruct the influencing factors of BIM technology in the operation and maintenance stage, and adopt a more scientific method to analyse it, so as to put forward the strategy of popularizing and applying BIM technology in the operation and maintenance stage.

2. Construction of obstacle factors affecting the Application of BIM in the stage of Operation and maintenance of Commercial buildings

With the expansion of the application scope of BIM technology, the application of BIM technology in the stage of operation and maintenance of commercial buildings has incomparable advantages over traditional methods, but there are still some problems in the practical application of BIM technology in the stage of operation and maintenance, such as few projects have been used, the degree of application is shallow, and the application effect is not ideal. This paper believes that this is because there are many internal and external factors that affect BIM technology in the operation and maintenance stage of commercial buildings. if one or several of them form obstacles, it will greatly affect the application of BIM technology in the operation and maintenance stage, as well as the overall effectiveness of operation and maintenance.

On the basis of interview data and literature research at home and abroad, this paper constructs the analysis framework of BIM application obstacles in commercial building operation and maintenance stage from four aspects, and establishes the hierarchical structure model of BIM application obstacle factors in commercial building operation and maintenance stage. Among them, standard, cost, technology and information are the first-level indicators. Legal provisions, industry standards, information standards, design costs, equipment costs, talent costs, software development, software compatibility, supporting hardware development, information integration, information update, information governance are secondary indicators.

Tab 1 limiting factors affecting the application of BIM technology in commercial buildings

First-level index	Secondary index	Explanation	Source
Standard	Legal stipulation	The laws and regulations for the application and promotion of BIM technology are not perfect.[1]	Mengchao Wang (2020)
	Industry standard	Lack of industry standards to guide the application of integrated BIM in all stages of project design, construction, operation and maintenance. [2]	Lianying Zhang, Yanwei Li et al. (2013)
	Information standard	The delivery format of building information model is not uniform in the process of BIM implementation. [3]	Huahui Lai, Xueyuan Deng et al. (2015)
Cost	Design cost	In the early stage, BIM invested heavily in parametric design, visual design, sustainable design and multi-professional collaboration. [4]	Zeng Tong, Daibing Wang (2014)
	Equipment cost	The cost of hardware facilities such as computers and sensors in construction enterprises is high. [5]	Zaijun Wang (2017)
	Talent cost	BIM professional staff is scarce, the salary is high, and the cost of education and training of the company is high. [6]	Wei Li (2016)

Technical	Software development	The related software functions are not intelligent enough, and it is difficult to master the software use technology. [7]	Qiuyue Shi (2017)
	Software compatibility	BIM software compatibility standards are not unified, and there is a lack of data sharing among different majors. [8]	Entian Luo (2016)
	Hardware development	It is difficult to develop the hardware and intelligent terminal equipment of BIM application during the operation and maintenance phase of the construction project. [9]	Jrade（2017）
information	Information integration	Collect project data accurately and completely, and then integrate and build the data through BIM[2]	Lianying Zhang, Yanwei Li et al. (2013)
	Information update	There are great challenges in real-time dynamic information management in the stage of operation and maintenance. [10]	De Xu (2018).
	Information governance	BIM Information as Enterprise Resources in Information Mining. Utilization and sharing are not effectively managed[11]	Khaja (2016)

3. Analysis of obstacles to BIM Application in the stage of Commercial Building Operation and maintenance based on AHP

3.1. Introduction of AHP method

AHP is a convenient and simple MCDM (multiple criteria decision making) method to solve the internal relations of complex problems. The principle of AHP is to first divide the factors in complex problems into related ordered levels, and then analyse the factors in the levels. The pairwise comparison strategy requires decision makers to compare all available demand pairs together to calculate the weight of one demand relative to another demand, give the corresponding quantitative representation, and then establish a judgment matrix. calculate the relative importance of each factor at each level to the target layer. It is especially suitable for solving the problem that it is difficult to analyse the countermeasures directly and accurately, and puts forward the corresponding countermeasures according to the relative importance of each factor.

Tab 2 scale value table

Scale value	1	3	5	7	9	2,4,6,8
Definition	Compared with the two elements A and B, they have the same influence.	Compared with element An and element B, the influence of element A is slightly greater than that of element B.	Compared with the two elements A and B, A has more influence than B.	Compared with the two elements A and B, A is much more influential than B.	Compared with the two elements A and B, the influence of A is absolutely greater than that of B.	Intermedia te value

3.2. Data source and processing

This questionnaire consists of two parts: the first part is about the work of the subjects and their understanding of the application of BIM technology, and its purpose is to investigate whether the respondents have a sufficient understanding of the application of BIM technology in operation and maintenance.

The second part is about the evaluation of the weight of the obstacles to the application of BIM technology in the commercial building operation and maintenance stage, and its purpose is to measure

the influence of various factors on the application of BIM technology in the commercial building operation and maintenance stage.

The time of the questionnaire survey is from May 3, 2020 to June 3, 2020.

Tab 3 details of questionnaire collection

Distribution mode	Number of copies issued	Number of recovered copies	Recovery rate /%	Remarks
Paper questionnaire	36	32	89	The 60 questionnaires are distributed as follows: 5 BIM employees in construction units, 6 BIM employees in design companies, 7 BIM employees in consulting units, 11 heads of BIM centers in construction enterprises, 5 BIM employees in supervision units, 10 employees in BIM software development companies, 5 BIM employees in property service enterprises, 2 university professors and 9 university students.
Electronic questionnaire	240	37	15	
E-mail	10	2	20	
Total	386	71	18	

Note: among the 71 questionnaires, 11 questionnaires were excluded because of their low understanding of BIM in the stage of operation and maintenance, and the data of the remaining 60 questionnaires can be used.

3.3 Data analysis

3.3.1 Establish a hierarchical model

This study combines the preliminary identification results of the obstacle factors of BIM application in the operation and maintenance stage of commercial buildings, and obtains the hierarchical structure model, as shown in figure 1.

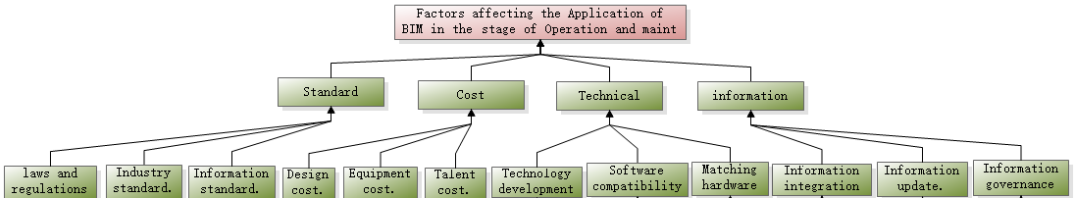

Fig. 1 hierarchical structure diagram

3.3.2 Consistency analysis

Through the establishment of the problem model of this study, combined with the results of the questionnaire survey, 60 valid questionnaires were calculated. If the C.R $\geqslant$ 0.1 of 25 data, the judgment matrix should be modified or discarded appropriately, and the consistency rate is 58.3%. The result can reflect the current BIM situation of commercial construction development and operation enterprises.

3.3.3 Construct judgment matrix

Because of the large sample size of 35 samples, the geometric average of each scale value of the questionnaire is taken when calculating the factor weight, and then a new judgment matrix is constructed. the judgment matrix of the first and second level index is shown in the table below.

Tab 4 judgment matrix of criterion layer and target layer A

A	design cost	equipment cost	talent cost
design cost	1	C12	C13
equipment cost	—	1	C23
talent cost	—	—	1

Tab 5 judgment matrix of standard layer and BIM standard layer B1

B1	design cost	equipment cost	talent cost
design cost	1	C12	C13
equipment cost	—	1	C23
talent cost	—	—	1

3.3.4 Calculate the total ranking of indicators at each level

In this study, yaahp software is used to calculate the survey results based on the above judgment matrix, and the combined weight of each index is obtained. The weight of each index is shown in the following figure:

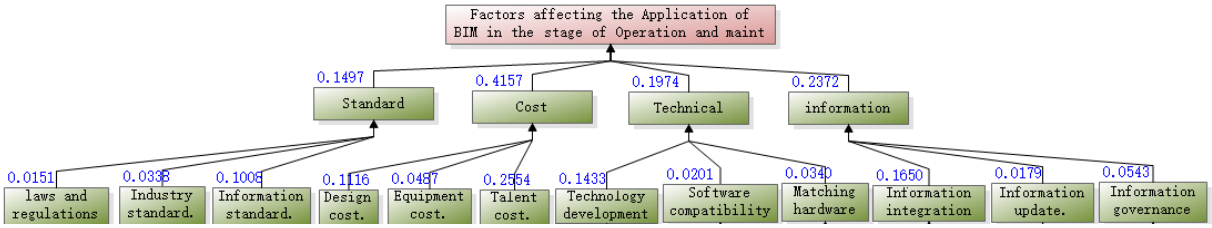

Fig.2 combined weights of each index

4. Conclusion

The obstacles to the application of BIM technology in the operation and maintenance stage of commercial buildings are affected by the government, enterprises and other subjects. In the stage of operation and maintenance, the key obstacle to the application of BIM technology comes from the cost factor, and its negative influence rate is as high as 41.57%. In terms of cost consideration, if we need to introduce BIM technology into the operation and maintenance management stage, we should carry out corresponding planning and design in the early stage, introduce professional BIM operation and maintenance team and supporting related equipment, so as to bring about an increase in short-term capital investment and hinder commercial construction development enterprises from applying BIM technology.

The influence degree of talent cost, design cost and equipment input cost is 25.54%, 11.16% and 4.87%, respectively. Among them, the demand for and insufficient training of specialized talents is the biggest obstacle. The main reason is that the current integrated talent market lacks the supply of corresponding professionals. In order to cope with the demand for technical services, if the company independently undertakes the allocation of BIM professionals, ability training, relevant theoretical knowledge learning and time education, it will certainly directly increase the cost input of the enterprise.

Obstacles at the information level accounted for the second, reaching 23.72%. The difficulty of information integration has the greatest impact on the obstacles at the information level. Operation and maintenance management not only needs to include the necessary information in the stage of design, construction, completion and acceptance, but also increases the new information needed by operation and maintenance, the amount of information is quite huge. Due to the characteristics of commercial buildings, such as many service providers, great differences in building functions and space requirements, complex and diverse construction equipment, large flow of people and vehicles, large comprehensive volume and so on, it is more difficult to integrate information. To do a good job of information exchange and cooperation at all application levels, it is necessary to do the interconnection among good people, equipment and buildings in order to reflect the value of BIM in the stage of operation and maintenance.

The impact of technology is 19.74%, of which technology development contributes the most. At the present stage, there is no domestic software that can play the full function of BIM technology in the stage of operation and maintenance. Moreover, the software development, testing and updating of BIM operation and maintenance have a huge workload, which requires a high technical level of R & D personnel. The impact rate of national laws and regulations on the application of BIM technology in the operation and maintenance phase is 14.97%, with the least impact. Among them, the influence of BIM industry information standard is greater.

5. Development suggestions.

BIM technology is an efficient and convenient tool, and the application of BIM technology to operation and maintenance management is a new management concept that can create great benefits for the operation and maintenance of commercial buildings.

(1) The expenditure structure should be optimized. If the property is owned by the owner, the enterprise should optimize the allocation of funds and carry out detailed cost control and audit accounting for the projects applying BIM technology, so as to avoid unnecessary cost waste.

(2) Train the enterprise's own BIM talent team, establish a talent incentive system, mobilize the enthusiasm of professionals, so as to reduce the cost of talents in the application phase of the project. Moreover, enterprises should change their thinking and accept the appropriate increase of capital investment in the early stage, so as to reduce costs and increase efficiency in the later stage of operation and maintenance, and at the same time reduce building energy consumption and resource investment, which is in line with the national development strategy of low-carbon buildings and sustainable cities.

(3) Pay attention to the integration and sharing of information, select the software that is beneficial to the information and data sharing of the participating parties and operation and maintenance enterprises, and rely on the introduction of national policies to unify the information integration, update and governance standards of BIM software, so as to promote the in-depth use of BIM technology in the stage of operation and maintenance.

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