Challenges and Benefits of BIM Adoption in a Metrorail Project

Sulakshya Gaur and Abhay Tawalare

Abstract Improper integration of different practices in the projects has always been a critical challenge in project delivery. Building Information Modelling (BIM) emerges as one of the important tools that help to facilitate this process. However, its implementation is not devoid of challenges and bottlenecks. With a case study on one of the Indian megaprojects employing 5-D BIM, this work enlisted eight major challenges encountered in its implementation. Further, these were grouped into three categories i.e., personnel issues, process issues, and technological limitations. Along with this, these challenges were mapped with the practices/steps adopted by the organization to overcome these obstacles. The detailed analyses also revealed that mutual consent between the four most important stakeholders i.e., client, consultant, designer, and contractor is of utmost importance for the implementation of BIM. The findings also revealed that BIM as a process can integrate various processes in the construction project and thus can pave a way for better management of stakeholders too.

Keywords BIM · Megaproject · Metro rail project · Project management · Stakeholders

1 Introduction

The disintegrated nature of the construction industry presents a humongous challenge for the efficient delivery of the projects. To overcome this pertinent crisis, several improvement tools have been developed to enhance the overall performance [1]. One of such tools that became popular among construction professionals was Building Information Modelling (BIM). BIM acts as an important tool in the modern-day construction process, that allows users to create multidimensional models for efficient project management during the life cycle of the project [2].

S. Gaur · A. Tawalare (✉)
Visvesvaraya National Institute of Technology, Nagpur, Maharashtra, India
e-mail: abhaytawalare@civ.vnit.ac.in

G. C. Marano et al. (eds.), *Proceedings of SECON'21*, Lecture Notes in Civil Engineering 171, https://doi.org/10.1007/978-3-030-80312-4_56

BIM, by its sheer ability to promote effective collaboration between groups and teams, enhances the flow of information thus promoting better communication [3]. This not only reduces the overall project time and in turn the cost but also helps a great deal in the reduction of the overall life cycle cost of the project.

However, BIM suffers from numerous challenges in its adoption and several previous studies have focused on identifying these factors. The previous studies have generally focused on the projects in various developed countries such as the United States and the United Kingdom. These research works have pointed out lack of human, technological and financial resources along with poor technical and managerial skills as major challenges to BIM adoption [1]. A comprehensive analysis of these factors remains absent concerning the type of project and also specifically about the implementation of 5-D BIM.

Taking these into account, this work uses an exploratory study to determine/assess the challenges the project team faced in BIM adoption in Mass Rapid Transport System (MRTS) i.e., a metro project in India. This becomes more important as the project considered in this study is the first to use 5-D BIM and SAP-ERP (Enterprise Resource Planning) in India and across Asia [4].

2 Literature Review

Collaboration between teams is described as the major link to achieve common project goals and hence certain practices need to be adopted to promote it efficiently. A shift from the traditional practice that heavily depends on 'non-intelligent/non-interoperable data' along with 2-D drawings needs to be undertaken [5]. Hence, to facilitate this process use of BIM as a tool becomes important. BIM greatly helps in the distribution/exchange of information between the participants and different teams, such as data transfer to teams during the O&M phase of the project [6]. The ability of BIM to integrate cost data provides an opportunity to designers and contractors to look into various alternatives and appraise them accurately during the initial stages itself [3].

Although the advantages of using BIM in the construction process are very clear, reluctance in its adoption is one of the major barriers to its adoption along with many other challenges it faces [7]. The role of top management (support from the top leadership) [8] along with the availability of proper financial resources is essential for the adoption of any type of innovation in the construction industry [1]. A coalescence of such previous studies reveals that the unavailability of resources and lack of skills among the project teams are the critical barriers to the implementation of BIM [1]. Moreover, these studies have a major focus on the projects in developed countries such as the USA, the UK, Canada, France Australia, Japan, and New Zealand [9] and but it is still a new technology in developing markets and suffers a slow adoption rate [10].

Hence, this study by focusing on the first metro project to employ 5-D BIM and SAP-ERP system in India tries to find out the primary challenges in the adoption of the whole system along with the benefits it has provided. 5-D BIM model is the one that integrates 3-D model with time (4th dimension) and cost (5th dimension). Cost-related information is provided using SAP-ERP. The challenges enumerated in this study along with the possible solutions may pave way for the implementation of BIM by highlighting substantial BIM advantages and hence its ability in managing some key stakeholders.

3 Research Methodology

The study uses a semi-structured interview approach to understand the ideas and challenges faced in the adoption of BIM in a Mass Rapid Transport System (MRTS) i.e., a metro project. An ABC (fictitious name) metro project in one of the major cities of central India was undertaken for the study. Since this project is the first one to employ 5-D BIM along with the SAP-ERP system, it was found suitable for this study. Data was collected with the help of semi-structured interviews and discussions with the project participants. The use of semi-structured interviews helped in keeping the discussion open with the respondents. In some instances, a detailed insight was sought from them to understand some of the challenges and obstructions in better ways. Moreover, using this method they provided detailed information about their experience in using BIM as a tool and a process.

A thorough literature study was done before the preparation of questions for the interviews. This helped in obtaining some initial ideas about the basic bottlenecks in BIM adoption and also helped in keeping the conversations with the respondents fluent. The interviews were conducted for a period of 2 months and a single interview lasted for a duration of 45 min–1.5 h. Eight project personnel were interviewed during this duration and all of them belonged to the senior managerial positions and had hands-on experience in using BIM as well as managing the overall project. These participants belonged to different sections i.e. planning, design, procurement, and IT. Moreover, these respondents were limited to general manager, executive director, assistant general managers. All the respondents had extensive experience in their relevant fields and were deemed suitable for this study.

The interview data were analyzed using NVivo 10. All the challenges towards BIM implementation were coded as child nodes during the initial analysis. Once the initial coding process was completed these child nodes were grouped under the constructs/parent nodes. These parent nodes were then named based on respondents' input and previous literature.

4 Results and Discussions

The analysis of the interviews presented major challenges the project team faced in the BIM adoption. The analysis of the interview data presented eight major challenges they witnessed in the adoption/implementation of BIM in their project. These challenges were grouped under three constructs i.e., personnel issues (1st construct), process-based issues (2nd construct), and technological limitations (3rd construct). The inhibition of personnel towards technological advancement i.e., unwillingness to accept change was the highest coded factor in the 1st construct followed by lack of skilled personnel for using BIM. In the 2nd construct, both, difficulties in adopting new technology and huge upfront cost in BIM adoption were equally important challenges. The third construct dealing with the technological limitations had the poor IT (HW, SW, and network) infrastructure as the most coded factor.

Apart from this, the respondents mentioned few strategies that they had adopted or that need to be brought in place to facilitate the BIM adoption process. In this, the most important were training and education of employees and a need for strong government mandate and BIM standards. These two factors were coded in all the conducted interviews. The next strategies were having strict contractual provisions and laws followed by publicizing the advantages of BIM and having indigenous software and better IT infrastructure. The content analysis of the interviews done through NVivo is presented in Table 1 below.

The interview respondents along with discussing the challenges also detailed the benefits BIM has to offer. The advantages are witnessed in better collaboration of different teams and groups for reaching an optimum design and solutions. This along with the ability of BIM integrated with ERP platform provides for quick approval of bills and reduction in manual cataloging of office documents. By providing a virtual workspace, BIM brings different teams together during the planning and design stage itself. This leads to better creation of designs and reduces any future reworks. Because of numerous advantages, it becomes important to better address the inefficient adoption of BIM. To present the challenges along with the critical strategies that can be adopted to overcome those challenges a conceptual model is prepared and is presented in Fig. 1 below. This is followed by a discussion on the challenges faced in the BIM adoption in a metro rail project.

Challenges to BIM adoption:

4.1 Personnel Issues

The lack of a sufficient BIM skilled workforce in India calls for an extensive training regime of construction personnel with the new technology to provide them with hands-on experience of software usability. Not only the training of existing employees but to develop a better future workforce, BIM needs to be incorporated

Table 1 Results of the content analysis of the conducted interviews

Constructs	BIM Challenges	Sources	References	% Articles coded
Personnel Issues	Unwillingness towards technological advancements	6	10	75%
	Lack of skilled personnel with BIM usage	5	13	62.5%
	Draining and outsourcing of workforce	2	2	25%
Process-based issues	Adaptability with the new platform	5	7	62.5%
	Huge upfront cost in the project	5	8	62.5%
	Lack of mutual consent between important stakeholders	2	5	25%
Technological limitations	Poor laws pertaining to data protection and privacy	4	6	50%
	Poor hardware, software, and networking infrastructure	5	9	62.5%
Strategies (that can be) undertaken to facilitate BIM adoption				
Strategies		**Sources**	**References**	**% Articles coded**
Training and education of employees		8	13	100%
Publicizing the advantages of BIM		4	7	50%
Strong government mandate and BIM standards		8	15	100%
Strict contractual provisions and laws		6	11	75%
Development of indigenous software and better technical infrastructure		3	5	37.5%

in the curriculum too. One of the other issues that act as an add-on to this lack of a skilled workforce is the draining and outsourcing of the workforce. India being a diversified country, possess a skilled workforce too who are well accustomed to BIM and its uses, but their shifting to work for international companies and projects makes it difficult to find suitable designers and consultants for indigenous projects. This area was explained by one of the experts as:

> It is not that there is a lack of talent pool in India. A lot of young professionals who are coming out are very competent and extremely skillful, but the lack of job opportunities and less pay means they are easily lost to our foreign counterparts. This is where governments' role comes to the forefront, they must strive to provide better job and working conditions to young professionals to keep them attracted locally so that it will provide a great impetus to the Indian construction industry at large.

Apart from the lack of knowledge about a particular platform or the software the mere adamant nature of senior employees or management poses a strong obstacle for application or bringing in any new technology in the system. The unaccepting

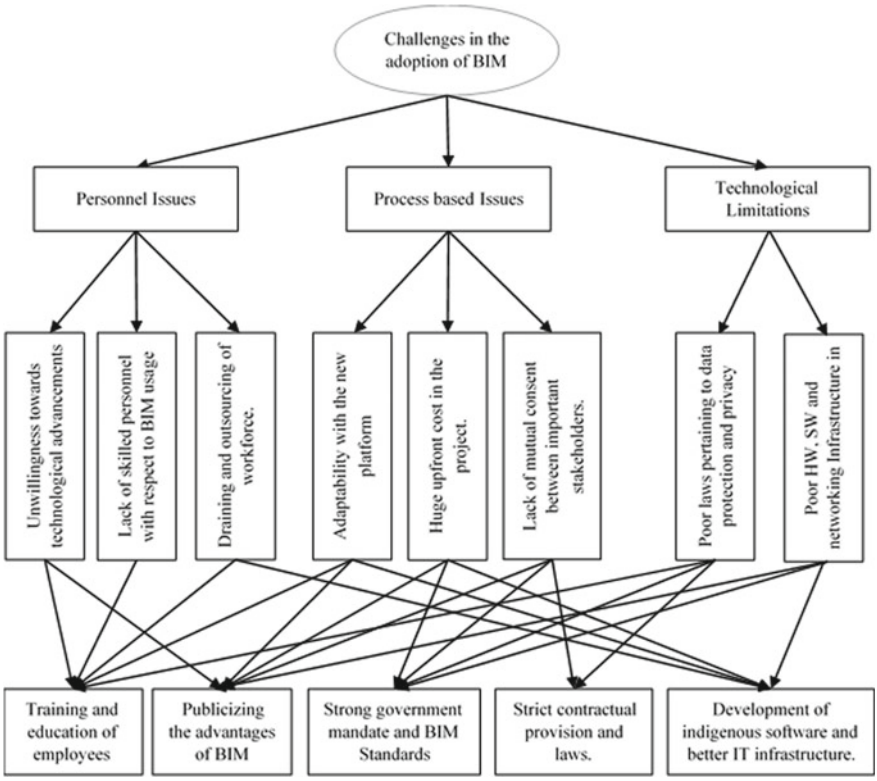

Fig. 1 Challenges to BIM adoption and strategies for its resolution

nature of the top management or the senior employees in the system makes the overall process of changing a system or inculcating a new methodology in a set process very daunting. Although this can be the result of both, either their inability to adopt a new process or it can be a result of their rigorous attitude to not change.

These major roadblocks to the adoption of BIM can be resolved to some extent by having better training and education of the employees. The advantages BIM is going to offer in their day-to-day task can also be used as a motivating measure for facilitating its adoption.

4.2 Process-Based Issues

The second set of challenges towards BIM adoption was more related to the BIM process itself, although the BIM as a platform is quite user-friendly and is very advantageous, due to the integration of different tasks, a lot of users face difficulty in adapting to it. Secondly, the regular training of the existing workforce along with

developing new technical infrastructure that comes as a mandatory prerequisite for its adoption makes it a costly affair. This means, that a lot of small and medium-sized firms tend to avoid it. Apart from all these, the mutual consent between the four most important stakeholders in construction projects i.e., client, contract, designer, and consultant are extremely important for the BIM adoption. This was explained in more detail by the respondent as:

> This group (i.e., client, general contractor, DDC, and consultant) acts as the driving wheel to the project. Any conflict between these groups leads to delay in and in any extreme case leads to the project being shelved. Hence, for any new technology to be incorporated it becomes extremely essential for their mutual consent. A lot of time, the client (who is accustomed to the benefits of BIM) approves for its use but then the contractor opposes it on the part of huge investments that need to be done to accommodate its usage in the project.

This issue can be resolved by better educating the associated parties on the long-term benefits of using BIM in the project so that they are more than ready to use it and harness its complete benefits. Also, in such cases, the role of government comes out to be extremely important. The government should mandate the BIM usage in certain projects so that it becomes mandatory on the part of stakeholders involved to follow the set directions. Accordingly, the contract should be designed to take into account these mandatory mandates and standards so that there is no scope of conflicts at a later stage.

4.3 Technological Limitations

The advancements in the technologies have resulted in automatic protection of privacy owing to the increase in technicalities and reduction in human intervention. However, these still sometimes threaten privacy infringement [11]. Collaboration between different groups and participants along with a huge flow of data serves as a backbone of BIM. However, in this process of collaboration and data sharing, it becomes extremely difficult to decide the ownership of data [12]. Therefore, it becomes extremely important to manage these two important legal risks i.e., Intellectual property and having a clear picture of data ownership [13] associated with BIM. Apart from the data protection problem, the investment in developing a huge technical infrastructure for BIM also poses a serious challenge to its adoption. The collaboration of different groups on a single platform results in the churning of huge data that needs to be stored efficiently and directly results in huge upfront costs. This can be dealt with by having clear coordination between the client and contractors where they can come in agreement and share the fees and expenditure. An excerpt from the interview with the expert revealed certain strategies they adopted towards data protection is:

> We had a strict policy about data transfer and data ownership. To further protect it, access to the particular group was only provided who were associated with that task. For example, the design team and the DDC were only provided access to the designs and once the designs were approved by the team, then the contractor was provided access to that particular drawing and it was marked as Good for Construction (GFC).

As for the increased cost in the establishment of infrastructure, the stakeholders need to be able to witness the long-term benefits that can be obtained by the BIM usage and hence willing to make the initial investment upfront.

5 Conclusion

This article through a case study on a metro rail project presents the challenges encountered in the implementation of BIM in the project. Through a generated conceptual model, it provides certain strategies to overcome those barriers and efficiently aid in its implementation. The findings of the interviews with the experts revealed results related to lack of standard manual and documents for BIM implementation lack of attitude of managers, managers insufficient knowledge of BIM, increased cost as a result of BIM adoption as the important challenges faced in its adoption. The major findings suggested overcoming those challenges are the training and education of the existing workforce and also the new professionals. Also, a stakeholder-based ecosystem presented the advantage BIM has to offer in bringing different teams and groups together for better coordination, and collaboration of the workforce. This advantage of BIM will certainly aid the stakeholder management process and will lead to better execution of the project.

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