Effects of Applying BIM on Facility Management for Existing Buildings

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Abstract

Building Information Modelling (BIM) is increasingly being used construction projects, and it demonstrates its ability to improve the construction industry's performance, However, its application in facility management still moderate and has not yet reached the potential and expected full use. The most common problem facing facility managers is the ability to access and manage the information. Information is the key to operate existing buildings and most importantly is the ability to collect, analyze, and handle it in an appropriate manner to be used for the facility management phase and the entire building life. However, there is insufficient understanding of the correct standards, processes and policies to be followed in the submission and management of such data, a significant lack of professionals and lack of knowledge of their software. This study aims to explore the value of BIM and the challenges affecting its application in FM, as well as address the information required for effective facilities management in existing buildings and the challenges to maintain a continuous update of BIM information in FM. The research methodology is based on analytical method: Using a questionnaire to a sample of staff and engineers in facilities management to detect the effects of applying BIM to facility management. The research demonstrated the importance of creating a BIM model for existing buildings and its effects to improve operations and maintenance, the need to increase BIM practices in engineering organizations. and indicated the most important benefits of the BIM for facility management application as: increase the efficiency of operation and maintenance staff's access to data, improve future operation design and preventive maintenance, facilitate decision-making throughout the operation and maintenance phase, and finally reduce costs and time while increase the quality of procedures.

Keywords: (BIM) Building Information Modelling, (FM) Facility Management, (BLC) Building Life Cycle, (O&M) Operations and Maintenance, (LOD) Level of Details/Development, As-built, (PM) Preventive maintenance, (CM) corrective Maintenance, (DT) /Digital Twins, (IOT) Internet of Things

1. Introduction

"Adoption of Building Information Modelling (BIM) has increased significantly over the last few years"[1]. Interest in applying BIM in the construction industry has recently increased, especially in the early stages of construction, despite the important results achieved by BIM in the design and construction phases, the use of BIM in facilities management is relatively new and has not yet reached the full and expected use. Even the concept of FM is not common in Syria yet, and several challenges

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prevent owners from making full use of BIM as well as a limited understanding of how BIM can effectively support current FM activities.

“The Architectural, engineering, and construction (AEC) industry projects in Syria struggled with myriad problems. Building Information Modelling (BIM) technology worldwide proves its capability to solve these issues, Syrian AEC companies are rarely using BIM” [2]. “Results of the project management maturity assessment questionnaire showed poor performance with respect to the applicable project management techniques and methods” [3]. “Although Building Information Modeling (BIM) is widely adopted all over the world, it is still considered a new approach in Syria” [4]. “Facility Management (FM) regards the management of buildings’ assets and requires the administration of a large amount of data that must always be available, but today, they still consist of paper documents, which are susceptible to loss. This is one of the principal causes for costs increase in the Operation and Maintenance (O&M) phase, together with the lack of interoperability and communication. In recent years, the construction industry has been undergoing a process of digitalization, supported from the advent of new technologies that hit the market at low prices." [5]

This study aims to explore the value of BIM and the advantages of effective integration between BIM and FM in terms of providing pre-defined required maintenance, increasing the daily work efficiency of operations and maintenance, and achieving cost and energy savings, leading to improve projects performance. "The study proved the correlation between project management maturity and project performance, represented by cost and duration deviation coefficient." [6]

1.1. FM Concepts:

According to ISO vocabulary FM is: “Organizational function which integrates people, place and process within the built environment with the purpose of improving the quality of life of people and the productivity of the core business” [7]

According to IFMA: “FM is a profession dedicated to supporting people. It ensures the functionality, comfort, safety, sustainability and efficiency of the built environment - the buildings we live and work in and their surrounding infrastructure” [8]

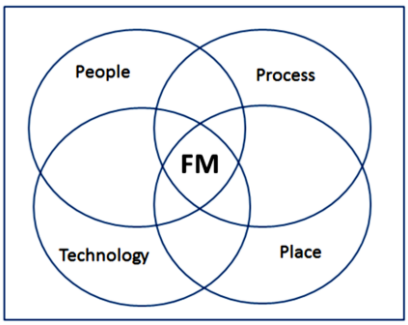

Figure 1 Facilities management concept (Source: IFMA, 2018)

1.2. BIM Concepts:

The American Institute of Architects (AIA) defined BIM systems as Building Information Management as follows: "The process that provides benefits that are evident through the electronic model, encompasses centralization of information, visual communication of building elements, sustainability, efficient integration of various disciplines, quality control, site organization, and more accurate operational schemes." [9]

The General Contractors' Federation of the United States of America defined BIM as follows: "It is the development and use of a computer software model to simulate the construction and operation of origin. The resulting model, the Construction Information Model, is a digital representation of the rich, two-purpose, intelligent and parametric origin through which to extract and analyze scenes and data appropriate to the different needs of users, to generate information that can be used for decision-making and to improve the delivery of origin. " [10]

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1.3. LOD, Level of Details, Level of Definition, Level of Development

The required level of 3D modelling (which objects are included in the model and the degree of detail by which each object is modelled) should be carefully determined depending on BIM goals and model uses during different project stages. Many organizations and BIM implementation plans identify LOD as requirements for sub-system projects at different stages. Low LODs are usually used for design (100 to 300) and top LODs for construction (300 to 400) and rotation (500).

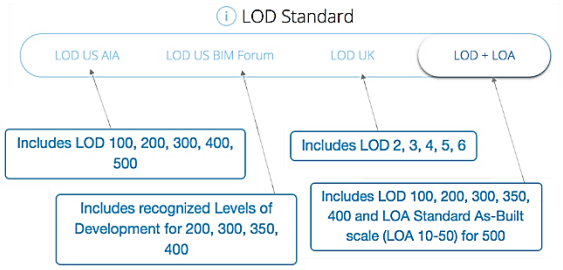

Figure 2 LOD Standard (lodplanner.com)

2. Literature Review :

Previous research papers indicated the drivers and barriers of using BIM in facilities management, mostly theoretical and emphasized the need for more applied research, and although it was unanimous that the most common problem facing facility managers was access to information. few studies included the difficult aspects of developing and providing such information in the context of real-world projects with owner-specific information requirements.

On the other hand, literature reviews showed that application of BIM at the FM phase is still weak and not reached the expected level due to poor awareness of its importance and its non-inclusion from the early stages of the projects and the need for a lot of resources and funding to apply in the case of existing buildings. “There is still a limited understanding of how BIM can effectively support existing FM activities and how it impacts current design and construction processes in practice, which compromises the definition of clear and efficient information requirements” [11].

Studies included several study cases of facility management models based on technology and techniques associated with DT and IOT, but this remote control has not yet been widely disseminated. “The results show how FM and the implementation of technologies in its practices, such as Building information modelling (BIM), Internet of Things (IoT) and Digital Twin (DT), are fields with exponential growth in recent years. Other technologies, such as blockchain, artificial intelligence (AI), machine learning (ML) and augmented reality (AR), emerged as part of digitalization in FM, which is part of the transition towards Construction 4.0” [5]. “To stay competitive, facility managers embrace technology as a way to delegate tasks, increase the productivity of the workforce, and improve customer satisfaction. The Internet of Things, among other technologies, helps build an all in-one environment for tracking all aspects of facility management — finance, paperwork, customer service, etc.” [12]. Some limitations have also been identified, “Despite the advantages of the presented approach, some limitations can be identified, such as the need to comply with the data structures of external information, with data format requirements that must be followed by the users to enable data import into the BIM. In addition, changes in the geometry of the model, e.g., splitting or merging adjacent rooms, imply the reallocation of attributes from the altered spaces and a new definition of the linkage to the external database structure” [13].

2.1. Table 1: BIM Benefits for Financial and Business

Item	BIM Benefits	References
1	Ease the decision-making process throughout the O&M phase	[14], [15]
2	Benefits from DT and IOT technologies to FM exceed their high costs	[15], [12]
3	Reduce the overall O&M phase cost in the long term.	[14], [16]
4	Cost saving, maintenance, convenience and control of occupants.	[16], [12], [17]
5	Efficient use of energy	[15], [18], [19]

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2.2. Table 2: BIM Benefits for Strategy Management

Item	BIM Benefits	References
6	Enhance the O&M future design	[14], [18], [20]
7	Improved responsiveness to owner's requirements	[21]
8	reduce the limits of current FM practice	[5], [20]
9	Develop strategies that lead companies to be competitive in this industry	[15], [17]
10	Mitigating environmental and social challenges	[15], [22]

2.3. Table 3: BIM Benefits for Operation and Maintenance

Item	BIM Benefits	References
11	Increase the efficiency of accessibility of the O&M personnel to the data.	[14], [13], [23]
12	Clearer management of the building space	[18], [20]
13	IoT-enabled workplace increases the productivity and health of occupants	[12]
14	More efficient implementation of maintenance work (renovation) and changes to completed buildings (reconstruction)	[16], [18]

2.4. Table 4: BIM Benefits for Projects Management

Item	BIM Benefits	References
15	Create a database for all the crucial O&M information for the O&M stage of the facility throughout its life cycle.	[14], [24], [18], [13]
16	BIM-IoT technologies can be effectively integrated into six asset management functions: energy management, O&M management, space management, FM project management, emergency management and quality management	[15]
17	Provide a reliable database and integrated views for all facility systems	[14], [20]
18	Better management of the life cycle of the construction	[18], [25]

Many studies confirmed the benefits of BIM for operation and maintenance fields with study cases.

This article aims to motivate and give confidence to stakeholders to adopt BIM in the FM phase by identifying BIM benefits in the four field of Facility Management (Financial and Business, Strategy Management, Operation and Maintenance, and Projects Management). Also, to reduce the knowledge gap between FM expertise and the utilization of BIM throughout the O&M phase.

3. Recherche Questions:

1. What are the obstacles and challenges facing facility management?
2. What values does BIM add to facility management?
3. How important is to create BIM model for existing buildings?

4. Recherche Hypothesis:

The design and executing phases have always received the most studies, research and attention, and the participation of facility managers is often limited during the life cycle of buildings as they are invited only in the final phase of construction when the buildings are delivered to customers. Therefore, facility management personnel face a significant problem during the operation and maintenance phase where the data required for efficient and agile management of FM are either incomplete or insufficient, which found in existing buildings.

Using BIM in facilities management can add great value through documentation, quality control, maintenance, warranty data, service information management, energy, space, evaluation, surveillance, etc., and having a digital building information database will allow financial management and staff to make better and faster maintenance decisions and provide high quality performance. The same

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database containing the building's information can also support the optimal use of the building and its modification throughout the life cycle according to the requirements of each stage. “BIM applications are interactive and dynamic compared to two-dimensional plans and traditional study methods.” [26]

5. Recherche Methodology and Tools:

The research methodology is based on analytical method: Using a questionnaire to a sample of staff and engineers in facilities management to indicate the effects of applying BIM to facility management and the obstacles it faces.

6. Results Analysis

6.1. Research sample analysis

The questionnaire was submitted to a sample of 54 engineers and employees, 28% are working in the field of facilities management, and 42% working in the field of supervision. Those who work in areas relatively far from managing facilities make up about 30%.

As well as 76% have more than 5 years' experience including 41% have more than 10 years' experience.

Table 5: Research Sample Analysis

What is your current job position?	Numbers	Percentage
Supervision	23	42%
Planning	1	2%
General Manager	2	4%
Designer	5	9%
Facility Manager	2	4%
Site Engineer	9	17%
Maintenance Staff	11	20%
Section Head	1	2%
Total	54	100%

6.2. Indicate awareness’ degree of FM functions and application as well as the constraints and limitations

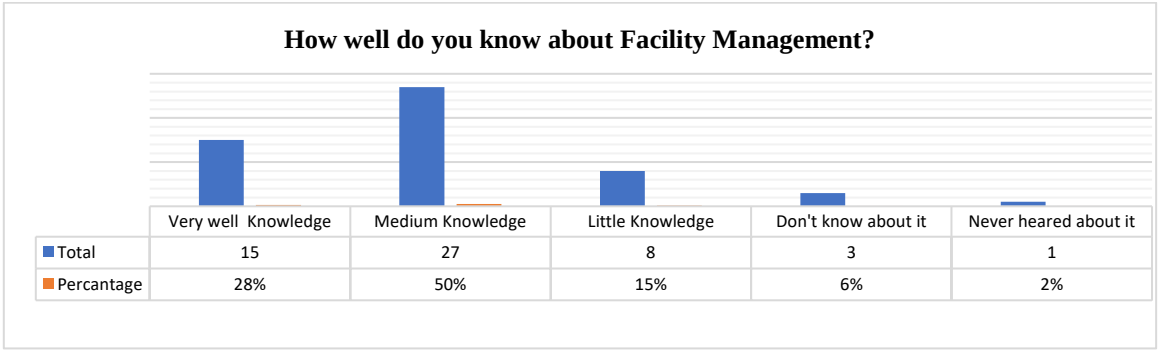

Figure 3 How well do you know about Facility Management?

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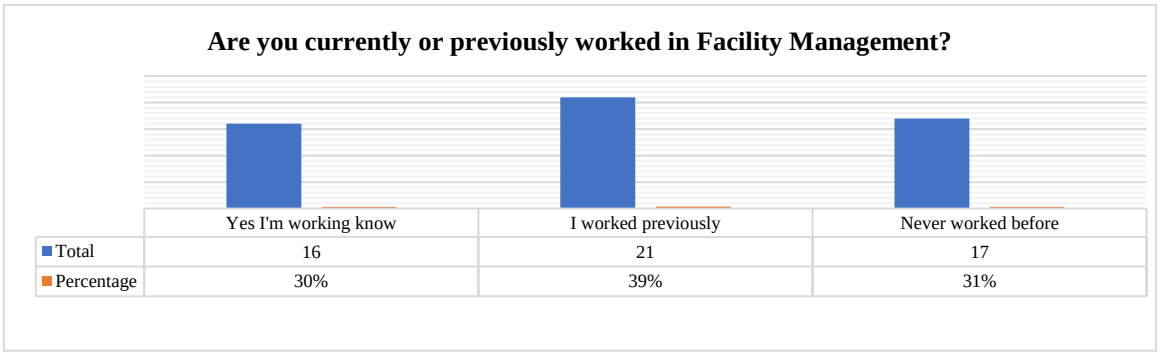

Figure 4 Are you currently or previously worked in Facility Management?

Analysis of sample distribution as figures 3& 4, shows that the higher percentage of the study sample 78% is aware of the importance of facility management and did work in it. The lower percentage is unaware of the importance of facilities management and did not work in it. Emphasis should be placed on this part of the sample and work to raise awareness of the facilities' management functions and operationalize their roles in existing buildings. This result conforms to the literature findings "In the field of operations, a better understanding of delivery methods is required." [27]

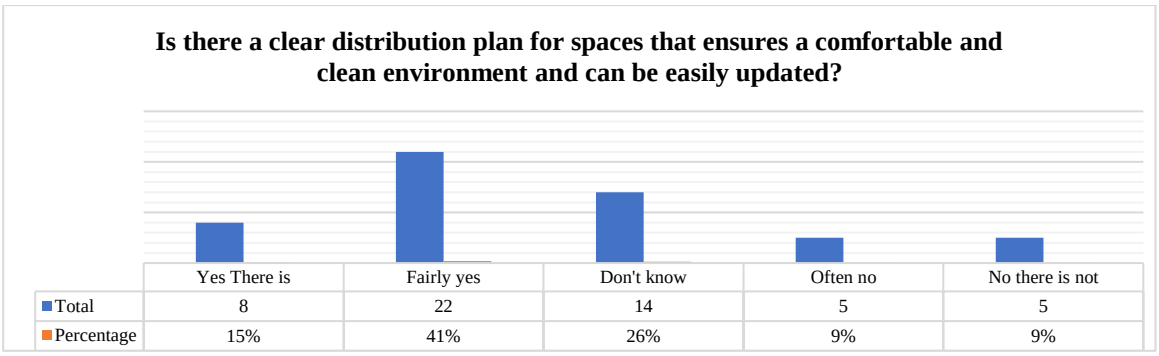

Figure 5 Is there a clear distribution plan for spaces that ensures a comfortable and clean environment and can be easily updated?

56%of individuals confirmed that there is a clear plan for space distribution and can be easily updated.as shown on figure 5. However, this percentage is low when considering that space management is one of the key and important areas of facility management. and therefore, must be improved.

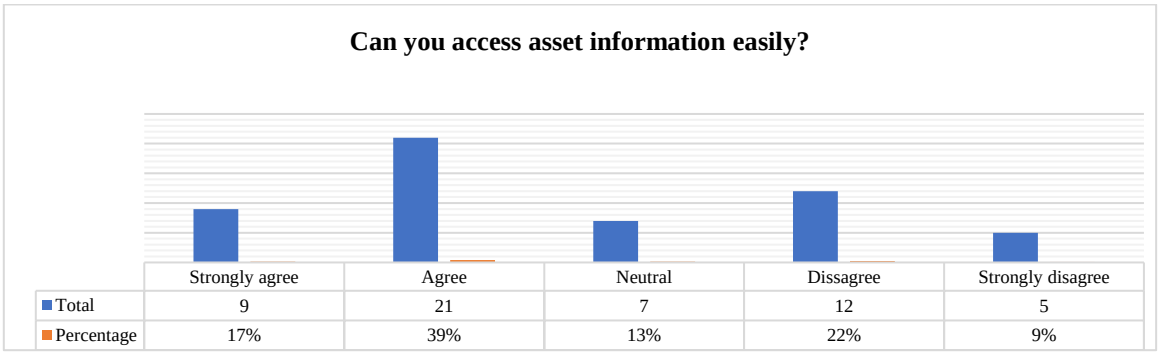

Figure 6 Can you access asset information easily?

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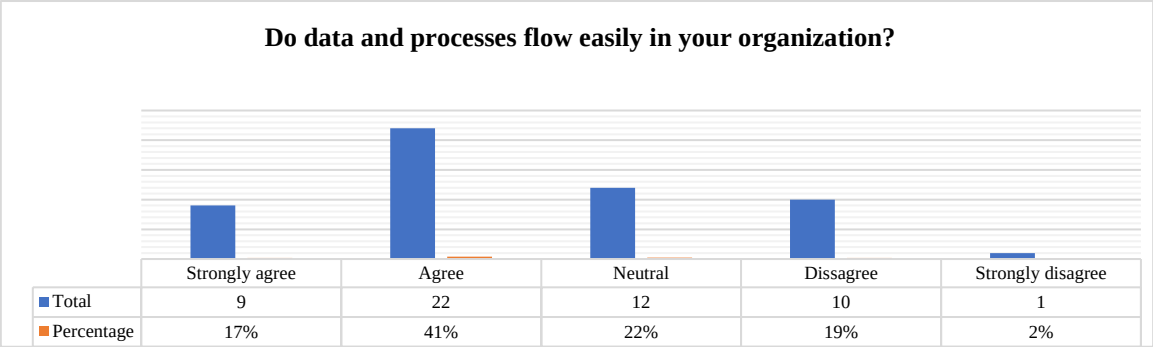

Figure 7 Do data and processes flow easily in your organization?

The number of individuals with easy access and flow of information reached about 57% of the sample, as shown on figures 6&7. However, the information is the basic database for effective control of facility management. The ease of data flow and operations affects the workflow, time and therefore cost and quality. These ratios therefore remain low and indicate the need for more effective solutions. (Roumieh & Ahmed, 2022) Suggested the following as risk response strategies "Provide regular feedback, document everything and use laser scanning technology and photogrammetry to collect the most detail, accuracy and in high quality". [28]

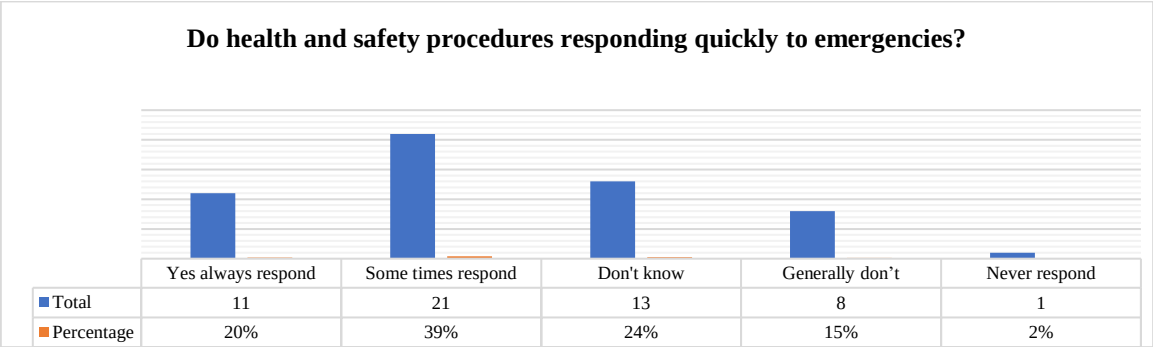

Figure 8 Do health and safety procedures responding quickly to emergencies?

According to 59% of individuals, health and safety measures meet the emergency's rapid response, while 17% deny it, as shown on figure 8. This ratio gives an insufficient indicator and needs to improve procedures.

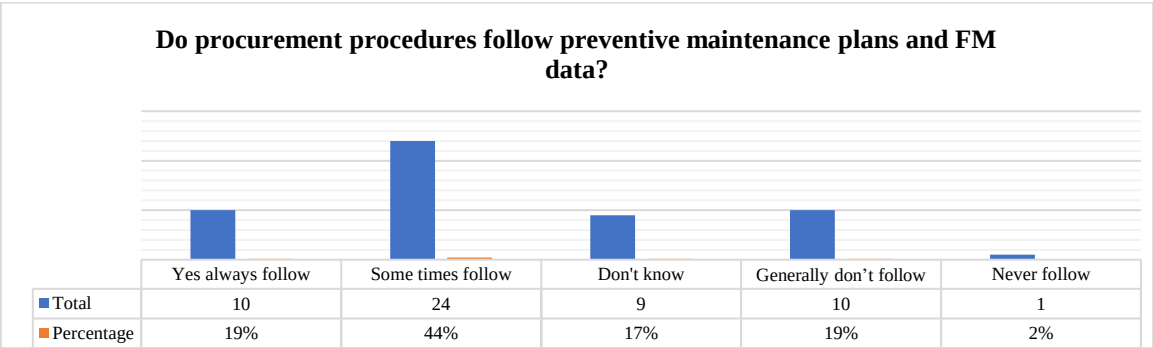

Figure 9 Do procurement procedures follow preventive maintenance plans and FM data?

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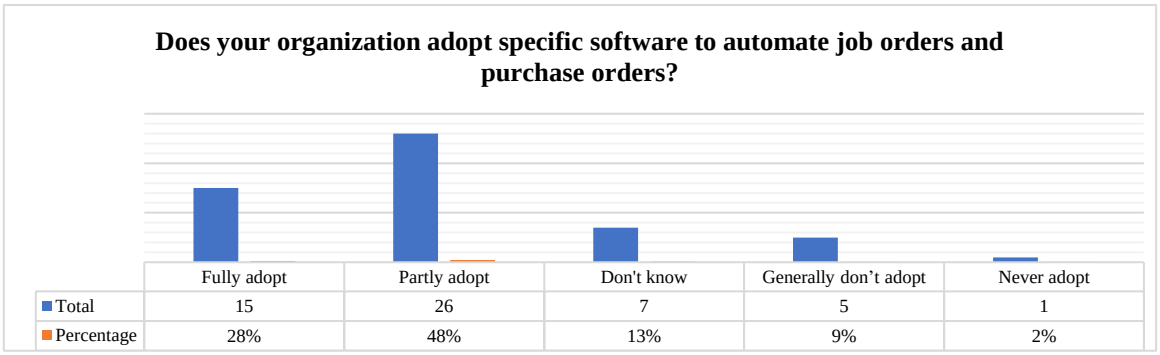

Figure 10 Does your organization adopt specific software to automate job orders and purchase orders?

%76 of individuals agree to digitalizing work orders and purchase orders at their organizations, as well as emphasize the role of effective maintenance management planning. As shown on figures 9&10. The next phase should therefore focus on developing programs to further operationalize the automation role in facilities management and effective budgetary planning. This result conforms to the literature findings "The integration of BIM during the project phases is also of a significant necessity, where some AEC companies in Syria started to adopt 3D models as the focus of the project works." [29]

6.3. Indicate BIM effects on Facility Management and what constraints its application

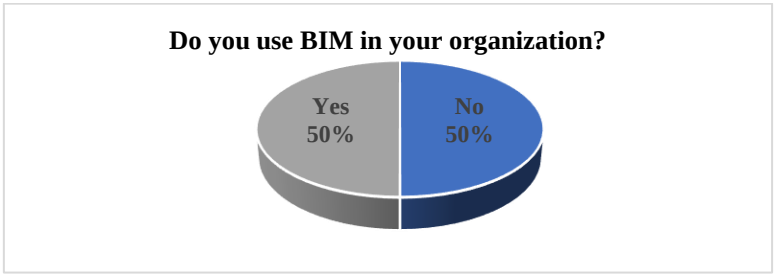

Figure 11 Do you use BIM in your organization?

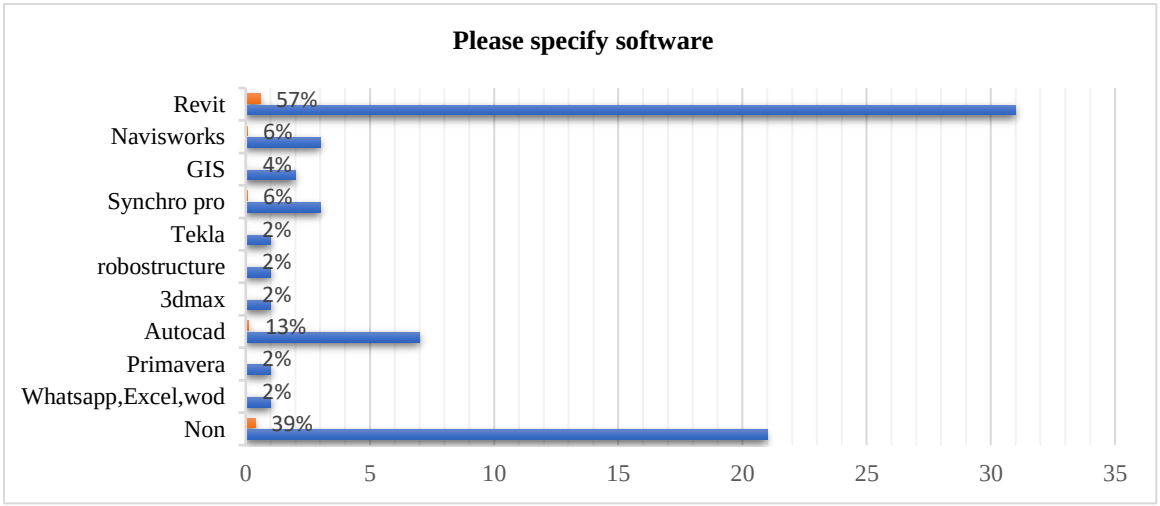

Figure 12 Please specify software

With 50% of the sample are using BIM and 57% of individuals tend to use Revit in engineering work. As shown on figures 11&12. This leads to a good indicator to build a base that can be relied upon in expand the use of BIM systems. While a small percentage uses another BIM software (GIS, Synchro Pro, Tekla, Navisworks, Robot Structural) which is a ratio that needs improvement.

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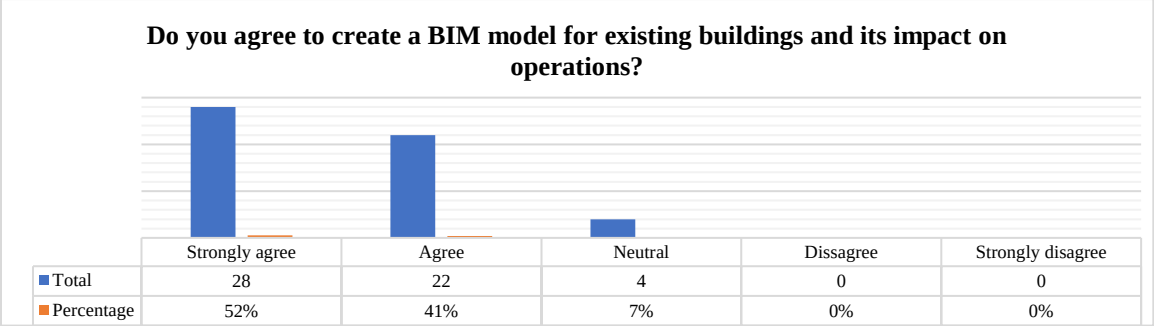
In other hand, some individuals of the sample considered that AutoCad, Primavera, 3dmax and others are BIM programs and this is an important indicator of poor awareness of the BIM concept. This result conforms to the literature findings "It is necessary to raise the awareness of institutions and companies in Syria about the importance of BIM, through conferences, seminars, and practical examples of countries that have applied this technology." [30]



	Strongly agree	Agree	Neutral	Dissagree	Strongly disagree
Total	28	22	4	0	0
Percentage	52%	41%	7%	0%	0%

Figure 13 Do you agree to create a BIM model for existing buildings and its impact on operations?

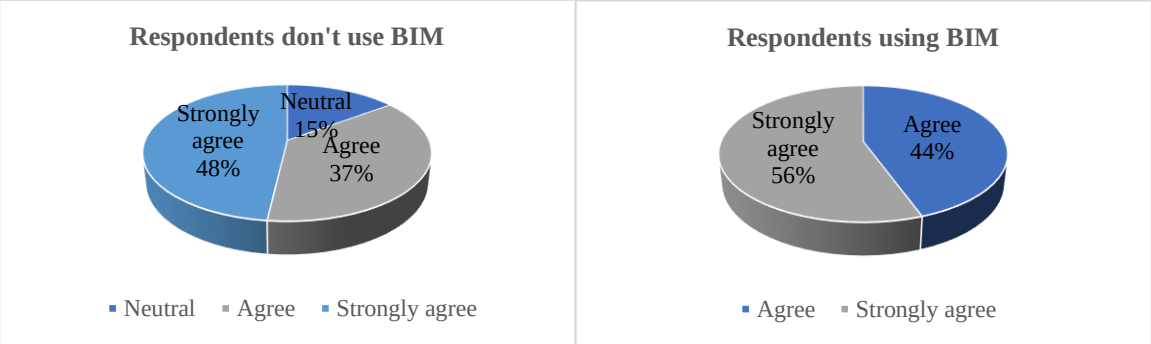


Figure 14 Respondents don't use BIM reverse Respondents using BIM

%93of sample individuals agree to create a BIM model for existing buildings,figure13. However, when determining the results of individuals using BIM in their institutions according to the first question of this section, the result is 100% of those agree to create a BIM model, figure 14. This presents an important indicator that can be relied upon to support applying BIM for existing buildings in general and support research hypothesis in particular.

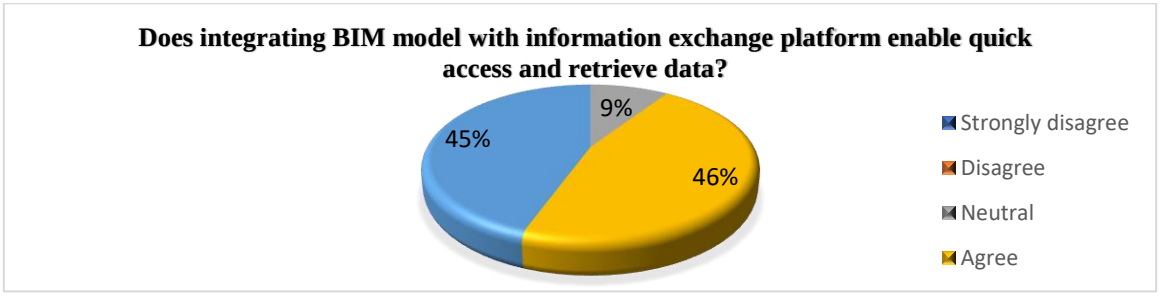


Figure 15 Does integrating BIM model with an information exchange platform enable quick access and retrieve data?

%91of sample individuals support integrating the model with an information exchange platform while there is no opposition, as shown on figure 15. This emphasizes the need to explore platforms that support BIM to serve engineering work. This result conforms to the literature findings "The need to invest in the engineering software industry and its applications in accordance with the BIM system." [31]

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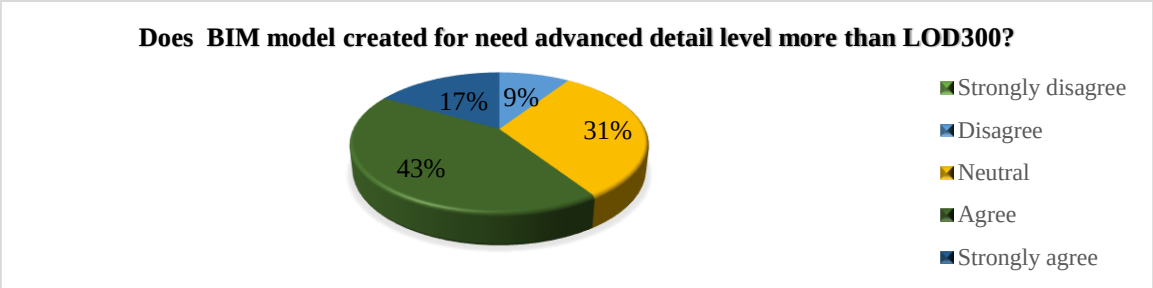

Figure 16 Does BIM model created for FM phase need an advanced detail level more than LOD300?

According to figure 16, Only %60 of individuals supports the need for LOD300 and above, to create FM BIM-model. This indicates the need to develop BIM education in general and LOD definitions in particular, as LOD500 represents As-built plans to meet operations and maintenance requirements. This result conforms to the literature findings "It was necessary for educational institutions to develop their curricula to keep of recent developments and digital transformation". [32]

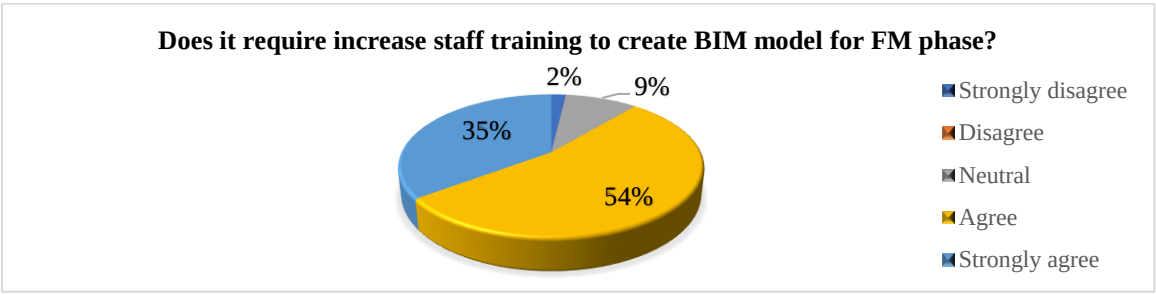

Figure 17 Does it require increase staff training to create BIM model for FM phase?

According to figure 17, %89of individuals emphasize the need to increase workers' training. This indicates the need for further training and development plans to optimize integration between BIM and facility management. This result conforms to the literature findings "Organizational decision makers have to support the staff, for example train the staff (short term), and put strategic plans in place to implement BIM. Every individual has to improve their BIM competencies." [33]

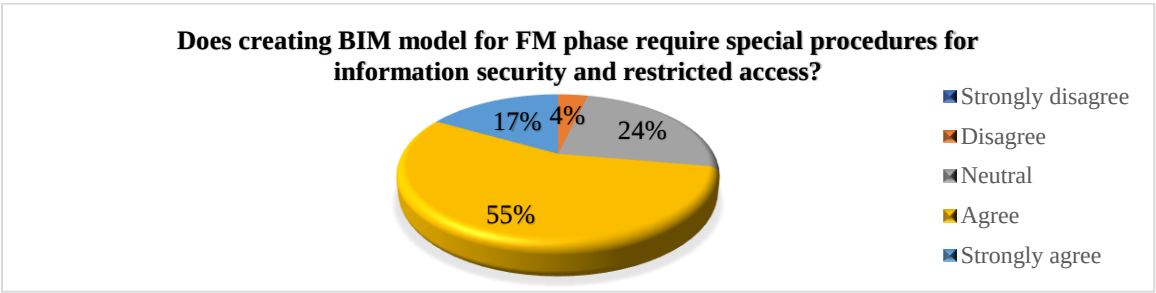

Figure 18 Does creating BIM model for FM phase require special procedures for information security and restricted access?

A high percentage of sample up to 72% emphasize the need for special procedures to ensure information security, figure 18. This indicates one of the most significant constraints to owners from using BIM. this leads to discover effective plans to increase owners' confidence in BIM.

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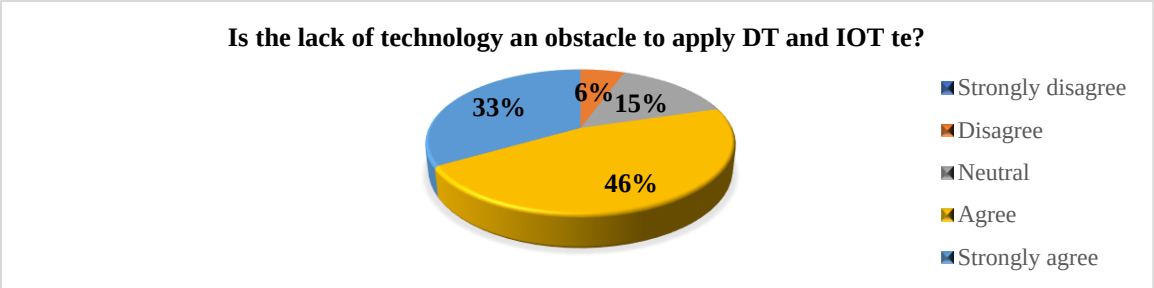

Figure 19 Is the lack of technology an obstacle to apply DT and IOT?

76% of individuals agreed that lack of technology is an obstacle to the application of digital twin technologies and the Internet of Things, figure 19. There is therefore an urgent need to develop current technology in Syria and to develop plans to update applications and technologies in line with the development of construction project management throughout the project's life cycle. This result conforms to the literature findings "Essentially, the development and adoption of BIM-related technology are significant for the building industry with regards to the global trend of adopting BIM and including it in plans of work." [34]

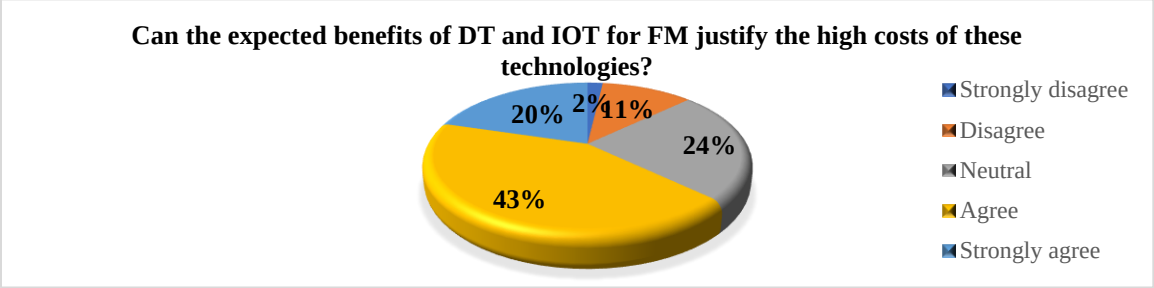

Figure 20 Can the expected benefits of DT and IOT for FM justify the high costs of these technologies?

As shown on figure 20, The percentage of individuals who find that the expected gains justify the high costs does not exceed 63%, which constitutes an obstacle to its adoption, and therefore the expected gains from the application of DT and IoT technologies to FM should be highlighted in order to justify the high costs. "The construction industry is one of the last industries to adopt modern technology because of its high cost and high risk of errors, even small ones." [35]

6.4. Indicate BIM values for Facility Management

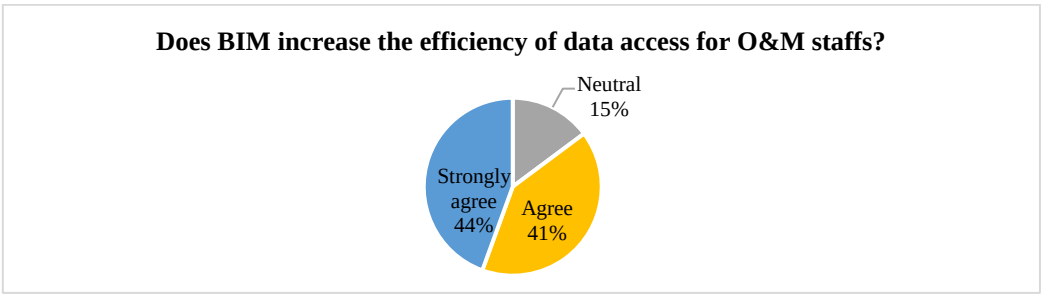

Figure 21 Does BIM increase the efficiency of data access for operation and maintenance staffs?

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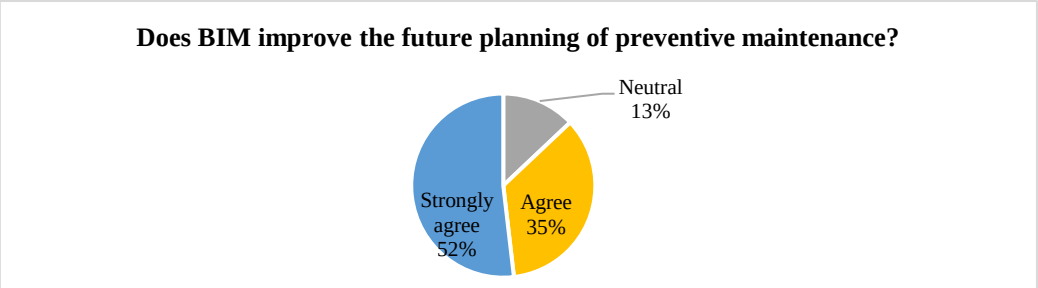

Figure 22 Does BIM improve the future planning of preventive maintenance?

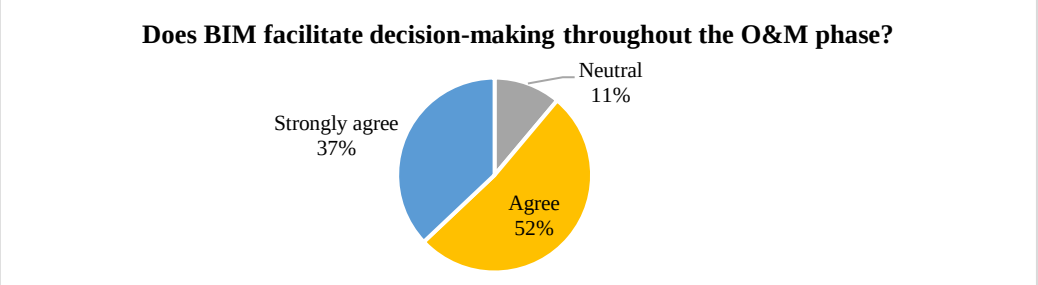

Figure 23 Does BIM facilitate decision-making throughout the operation and maintenance phase?

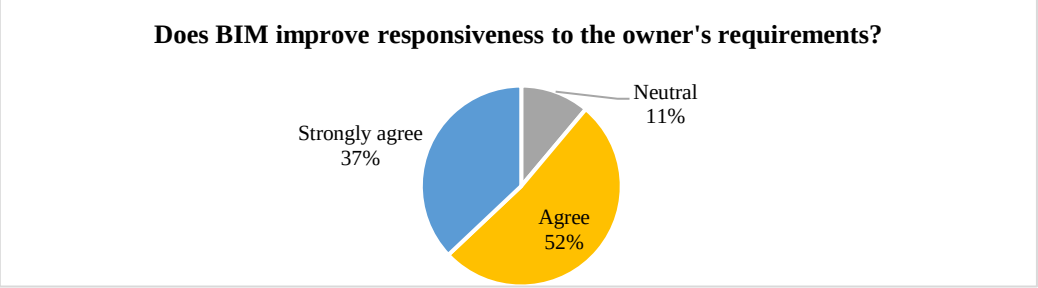

Figure 24 Does BIM improve responsiveness to the owner's requirement

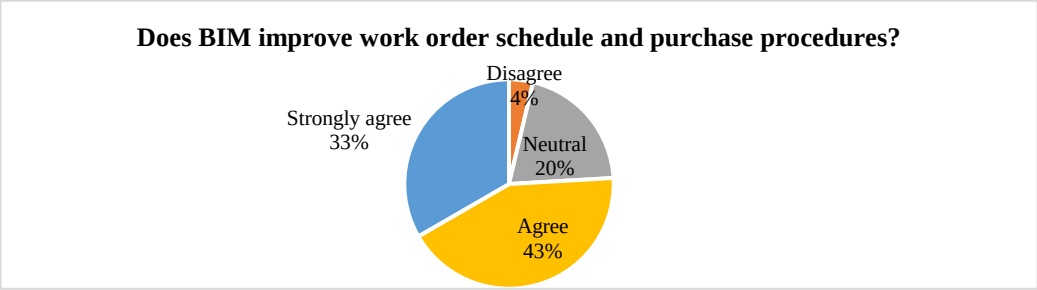

Figure 25 Does BIM improve work order schedule and purchase procedures?

Based on the sample's answers shown on Figures No.21,22,23,24, and 25. with ratios ranging from 76% to89%, BIM values for FM are:

1. Increases the efficiency of data access for O&M staffs, fulfilled with table 3.
2. Improves the future planning of preventive maintenance, fulfil with table 2.
3. Facilitates decision-making throughout the O&M phase, fulfil with table 1.
4. Improves responsiveness to the owner's requirements, fulfil with table 2.
5. Improves work order schedule and purchase procedures, fulfil with table 4.

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7. Conclusion

"Information plays a significant role in construction project management." [36]. Information is the key that plays an important role in effective facility management and then throughout the entire life cycle of the building (BLC). Through BIM information is handled fully efficiently through BLC. This study indicated the benefits of applying BIM for FM phase with needed recommendations: increase the efficiency of operation and maintenance staff's access to data, improve future operation design and preventive maintenance, facilitate decision-making throughout the operation and maintenance phase, and finally reduce costs and time while increase the quality of procedures. Also highlighted the poor access to asset information, data flow and processes in current facility management practices in Syria, leading to the importance to create BIM model for FM phase while based on, as well as Integrate BIM model with an information exchange platform enables quick access and retrieve data. The application of digital twin and IoT technologies can improve the efficiency of future facility management by providing a visual view of equipment and assets and synchronizing them with reality. "The importance of project participants recognizing the actual benefits of applying the BIM." [31].

Finally, the most important obstacle facing facility management found in the research is the poor access to information serving FM in existing buildings. "Information in the BIM form is often missing or added only at later stages of the project" [37]. The second relates to the lack of awareness and experience in FM-BIM applications, and difficulties in obtaining it in Syria. Also, the Difficulties in adapting to new BIM developments and challenges of modernizing them in existing buildings. "The most important recommendations indicate the need to enhance awareness of the BIM culture and its applications" [38]. With remarkable owner's concerns about data privacy and cybersecurity considerations. all constraint of adopting BIM for FM phase.

8. Recommendations:

1. Increase awareness of facility management in educational institutions, lectures and seminars and encourage institutions to activate their roles and applications in the life cycle of existing buildings. "Adopting digital transformation for the practical courses and link the new technologies in accordance with BIM to the reality of engineering work." [39]
2. Finding effective plans to increase owners' confidence in investing BIM through more applied research and providing encouraging results in terms of efficiency, savings, information security and extending facilities lifecycle.
3. The field of space management is a broad and important area to achieve optimal enterprise planning, properly identify and allocate spaces and support workplace productivity and essential linkages between employees. All the above can be achieved by applying BIM and exploring platforms that support BIM for fast, effective access and a clearer and more comprehensive vision as well as contributing to improving health and safety procedures to meet emergency rapid response.
4. Develop strategic plans to operationalize the role of digitization at all stages of construction and gradual transition towards the adoption of the BIM model, providing material, governmental, trade union and all facilities necessary to advance engineering work. [40]

9. Future Researches

This research will be followed by case study for modeling existing buildings and identifying the needed information to create BIM model that serves FM with all impediments and benefits. Research is also directed towards more research on digital twins and BIM technology in various sectors of the construction industry.

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