Challenges and Opportunities for Building Information Modeling in Facility Management: A Case Study from Egypt

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ABSTRACT

The objective of this study is to evaluate the obstacles encountered when using Building Information Modeling (BIM) in Facility Management (FM) within the context of Egypt. The research methodology employs a case study approach, using a single case study to investigate the phenomenon of interest. A comprehensive literature review was conducted, resulting in the identification of 42 challenges to BIM usage in FM. These challenges were classified into five primary groups and formed the basis for a five-point Likert scale questionnaire, which was utilized to collect insights from FM professionals in Egypt. The survey participants included facilities and maintenance managers, as well as BIM employees. The data collected were also analyzed deploying the Impact Effect Index (EI) method. Furthermore, the EI findings indicated that the primary difficulties were the integration of building system design with BIM, the establishment of handover requirements, the integration specifications between the FM and BIM, and securing accurate and reliable data. The category with the highest EI was challenges related to BIM implementation in FM. The research identifies the significant challenges affecting BIM adoption in FM in Egypt, thereby promoting the development of BIM implementation strategies. Consequently, the findings hold practical importance for various stakeholders within the construction sector in Egypt.

Keywords-Building Information Modeling (BIM); challenges; Facility Management (FM); integration of building systems

I. INTRODUCTION

The potential role of BIM for FM in the Egyptian Architecture and Construction (AEC) industry has emerged as a topic of increasing importance. Despite the numerous advantages BIM offers in terms of enhancing operational functional productivity, the implementation of this innovative technology is confronted with a multitude of challenges that require meticulous attention. In this context, it is essential to consider both the limitations and the benefits of using BIM in FM in the AEC industry to ensure a comprehensive understanding of its impact [1]. This study presents and compares the various advantages of incorporating BIM in FM with the numerous obstacles currently impeding its effective implementation. By recognizing the benefits and obstacles, potential actions can be more focused and practical, leading to improved strategies for overcoming barriers. The objective of this article is to respond to the key question of what are the reasons for employing BIM in the FM processes. The two focus areas in FM BIM are of great importance, as evidenced by the growing interest in the role of FM in the various functional stages that precede, occur during, and follow handover, as seen in both the FM and AEC literature. It is crucial to highlight that one of the roles of FM, in relation to value creation, may entail promoting integrated life cycle solutions for high added-value facilities [2, 3]. The value sought from this FM role is associated with value creation, which with regards to high added-value facilities is commonly connected with the essential capabilities they must accommodate. Therefore, the optimal strategy for FM decision-makers to add value is to ensure that the total life cycle cost of facilities is minimized without compromising service quality. This is consistent with the capability of BIM to address facility-related management throughout their life cycle, with the purpose of optimizing facilities' performance and services. The FM industry is undergoing significant transformation in the context of the Fourth Industrial Revolution (IR4.0), driven by the advent of new technologies. The advent of IR4.0 provides the construction industry with the potential for a transition towards more efficient production, business models, and value chains. Such changes can be achieved through the usage of the existing and emerging advancements that are essential for the IR4.0 paradigm. BIM represents a significant current advancement within the industry and is a collaborative approach that enables the development of an application framework involving the input of multiple disciplines engaged

in a construction project. BIM is defined as a set of interrelated methods, processes, and technologies that create a framework for the digital management of fundamental design and project information throughout the life cycle of a structure [4].

The adoption of BIM in the AEC/FM sector is growing at a rapid pace. However, despite the potential benefits that BIM offers to the FM discipline, the current approach remains largely focused on the design and construction processes. BIM is a promising technology that has the potential to significantly impact the way FM teams function and oversee their daily activities and offers a range of capabilities that can assist facility managers in executing their tasks with greater efficiency and efficacy. Data management is a crucial element of FM. A significant amount of pertinent data regarding the design, construction, and operation of FM are frequently misplaced or otherwise unavailable during the course of a building's life cycle. As a result, BIM is being employed as an effective tool to enhance a building's overall performance and facilitate more efficient and effective management and oversight of the operations throughout the building's lifespan [5, 6]. BIM can be applied in many FM activities, including commissioning, retrofitting, upkeep and repair, energy management, etc. The level of attention devoted to BIM in the AEC and FM industries has increased significantly over the past decade. This is evidenced by the growing adoption of BIM in developed countries [7]. Notwithstanding the growing recognition of the potential advantages of BIM, its adoption remains limited within the FM domain. This is particularly evident in developing countries, such as Egypt and the broader Middle East and North Africa (MENA) region. Although numerous studies have examined the challenges of BIM adoption in the AEC/FM sectors globally, few have investigated the specific challenges of BIM implementation in FM in emerging economies like Egypt [8, 9]. The multitude of intricate details, the vast array of issues and elements, and the necessity for collaboration, have been proven to essentially impede the operationalization of BIM. The boundaries that are evaluated to prevent the regulation of BIM are partitioned into five interconnected, interrelated, and interdependent classifications: techno-structure, software, and hardware; end-users, awareness of BIM education; policies, regulations; economy, cost-effectiveness; shared belief terms; BIM profit from investment, controlling defamation; errors, standard implementations [10, 11]. Rather than presenting these challenges in a linear sequence based on their perceived relevance or significance, the current study chose to adopt a multi-level structuration approach that reflects the iterative, sequential nature of the emerging RMID view. Consequently, the objective of this paper is to address the challenges impeding the implementation of BIM in the field of FM in Egypt, the impact of the aforementioned challenges on the implementation of BIM in the FM business in Egypt, the different challenges between large-scale and small-scale FM projects in Egypt, and the strategies that must be employed to mitigate the challenges and facilitate effective BIM implementation in the FM industry in Egypt. The relevance of this study in Egypt is contingent upon the country's ongoing pursuit of competitive development goals.

II. LITERATURE REVIEW

A. Overview of the Literature on BIM for FM in the Operation and Maintenance Phase of Buildings

In the initial stages of BIM, Graphisoft developed a software, ArchiCAD, in 1982, based on the BIM concept, or Virtual Structure, and was further developed in 1984 as the virtual structure model, marking the beginning of the BIM era. The United States public BIM standard portrays BIM as a digital representation of the physical and practical aspects of a structure, serving as a shared resource of information about the structure for making informed decisions throughout its life cycle, from the initial stages onwards. BIM offers a comprehensive understanding of a structure across its entire lifespan, with its application in FM being readily apparent. Nevertheless, the application of BIM in FM has been constrained, with the majority of emphasis being placed on the design and construction phases, even among prominent adopters [4, 12]. Notable successful BIM applications in the FM practice include the Sydney Opera House and Texas A&M Health Science Center. These examples demonstrate that while BIM is commonly employed in the AEC stages, its adoption in the FM stage has been slower among professionals. It is observed that, despite the recognition of BIM's advantages and its recent active implementation by FM professionals, numerous challenges persist, preventing its comprehensive adoption within the AEC/FM industry. The current status of BIM for facility management research is summarized, showcasing the distribution of document records directly related to the field [1].

B. Advantages of BIM in FM

The usage of BIM's 3D visualization and extensive datasets enables the support of a multitude of FM tasks, including maintenance, emergency management, and energy management. It is evident from building projects that BIM in FM has the capacity to considerably enhance the performance and operational management of buildings throughout their lifespan. BIM applications extend across the entirety of the resource lifecycle, spanning the domains of design representation, operations, and maintenance [9, 13]. Facility managers could use BIM for tasks, such as renovation, space planning, and maintenance [14]. It is highlighted that the BIM model has the capacity to manage project-related information from inception to completion, thereby providing valuable data for future stages during the structure's lifecycle. The incorporation of these data could facilitate enhanced building management and performance. It is argued that B.I.M. mitigates the risk of data loss when construction projects transition to FM, as it incorporates all historical and relevant details, facilitating seamless system integration for improved building performance and quality control. BIM generally assists FM teams by simplifying decision-making and integrating various facility management aspects [9, 16]. One effective method for studying the applications of BIM in FM is to consult with experts in the field. This may entail soliciting their perspectives on potential future directions for BIM. This may be accomplished through surveys and focus group discussions, which can provide comprehensive insights into potential or theoretical applications of BIM. Ten significant

challenges regarding BIM utilization have been identified in [16], with the ability to locate building components and convenient access to requisite data and information being the most crucial. Authors in [14] identified 18 potential challenges for BIM, the most significant of which pertains to its role in infrastructure maintenance and the availability of sufficient information to effectively manage and carry out the requisite operation and maintenance tasks.

C. Challenges Confronting the Usage of BIM for FM

A study conducted by members of the American Building Owners Association (ABOA) identified several significant challenges to the implementation of BIM in FM [17]. These include issues related to interoperability, ambiguity in delivery requirements, and a lack of comprehensive capabilities [18]. In the field of software and knowledge of BIM, it is also necessary to review the tasks involved in interoperability, the lack of defined standards, and the unclear handover procedures [19]. It is of vital importance for facility managers and designers to explicitly delineate handover requirements and to furnish comprehensive training to facilitate the transition to BIM data following construction. Another significant impediment is the inadequate understanding and social acceptance of BIM practices among building owners, clients, and facility managers themselves. The future of BIM in FM and maintenance will entail collaboration with subject matter experts. By employing techniques, such as interviews, surveys, and focus groups, the present study may be able to identify novel and prospective applications of BIM. Authors in [8] have identified ten key domains for BIM implementation, including real-time data access and enhanced visualization. Additionally, authors in [9, 10] have identified 18 advantages of BIM, particularly in the context of infrastructure maintenance and as a resource for managing maintenance activities. Nevertheless, the implementation of BIM in the FM industry is confronted with a number of challenges, which can be classified into five principal categories. The implementation is contingent upon the involvement of multiple key personnel, which can render the process challenging. Moreover, the management of data presents a significant challenge in ensuring the proper delivery and management of information. There may be difficulties in adapting to and understanding the technology behind BIM and even though the implementation of BIM may result in cost savings over an extended period of time, the initial investment in BIM systems could be considerable.

Finally, the usage of BIM may give rise to legal and organizational issues, which could cause concern regarding data accessibility, confusion, and the misleading transfer of information [7-9]. In conclusion, while BIM offers a range of benefits for FM and maintenance, its implementation is not without challenges. By understanding and addressing the latter, the FM industry could fully leverage the potential of BIM to improve efficiency, reduce costs, and enhance the overall building management experience. Various challenges associated with the implementation of BIM in the FM sector are presented in Table I. These constitute: the necessity for a diverse range of key personnel, data management during transfer and maintenance, industry impediments to the adoption and comprehension of the BIM cost-related challenges, including both the initial investment and long-term cost-saving benefits of BIM adoption, and the management of legal and contractual risks associated with the integration of BIM and FM, encompassing issues related to data accessibility, clarity, and the transfer of BIM-produced documents [18-46].

III. RESEARCH METHODOLOGY

This study employed a survey methodology to elicit insights from a diverse group of experts in the field of FM within Egypt. The objective of the study was to examine the incorporation of BIM into FM practices.

A. Participant Selection

The selection of participants is a crucial aspect of any research project. It was imperative that the focus be placed on the individuals involved in the FM phase who are actively engaged in the process of supervising or managing facilities during the construction phase. It is of great importance that participants possess a comprehensive understanding of the BIM systems and techniques, as well as their applications within the FM sector. The participants exhibited a high level of engagement, providing answers based on their experiences and professional practices. The data collection process entailed the administration of surveys to the participants. A total of 54 copies of the survey were distributed, and 52 were returned by the participants, resulting in a response rate of 94.54%. In light of the difficulties encountered in identifying the total number of facility managers in Egypt who possess BIM competencies, the sample was selected in accordance with the principle of obtaining as many subjects as possible for the purpose at hand [43-46]. This approach stresses the importance of considering practical limitations in the research plan. In order to ascertain the impact level of different elements taking into account the record values, researchers used a scale to quantify the magnitude of their influence:

$$Effect\ Index\ (i) = \frac{\sum_{i=0}^{4}(a_i)(x_i)}{4\sum_{i=1}^{4}(x_i)} \times 100 \quad (1)$$

where a_i is the weight assigned to i, x_0 is the recurrence of the Extreme Effect (EE) reaction relating to $a_0 = 4$, x_1 is the recurrence of the Strong Effect (StE) reaction relating to $a_1 = 3$, x_2 is the recurrence of Moderate Effect (ME) reaction relating to $a_2 = 2$, x_3 is the recurrence of Slight Effect (SlE) reaction relating to $a_3 = 1$, x_4 is the recurrence of No Effect (NE) reaction relating to $a_4 = 0$. The scale, which has been designated as continuous in x_i, represents the frequency assigned to i. The value assigned to i is 0, 1, 2, 3, or 4, as shown in Table II.

B. Data Analysis

Upon collection, the responses were subjected to a comprehensive and systematic analysis using the EI. This analytical method allows for the measurement of the study results and provides a framework for interpreting the data. The EI was determined by the method developed in [2], and subsequently refined in [3, 46]. This analytical methodology permitted an understanding of the impact of BIM on FM practices and facilitated drawing conclusions based on the results. The qualitative survey component of the study was subjected to a thematic analysis, thereby allowing for a more profound comprehension of the qualitative data collected.

TABLE I. CHALLENGES FACING THE UTILIZATION OF BIM FOR FM

No	Challenges	Description	Ref.
G1. Challenges connected with BIM execution in FM			
1	Allocation of BIM data ownership in the pre-design phase.	Interoperability is a key component of BIM technology, which minimizes the rework of BIM for numerous engineering objectives.	[6], [10], [12], [46]
2	Identification of key elements manageable by BIM.	Facility managers should leverage BIM to efficiently manage key building aspects, such as asset tracking, maintenance schedules, and space utilization. This enhances operational efficiency and supports long-term sustainability goals.	[2], [4], [12], [14], [46]
3	Identification of the level of detail needed from BIM.	Facility managers must identify the necessary data and details from the BIM system, which could range from basic specifications to in-depth performance metrics. This could be achieved through either fully automated or semi-automated systems to enhance operational efficiency.	[3], [4], [10], [20], [21], [47]
4	Identification of key items manageable by BIM.	Key items for BIM integration, such as asset information, maintenance requirements, and energy performance data, should be specified during the design and construction phases. This ensures seamless alignment with the facility management tasks for improved operational efficiency.	[13], [20], [22], [23], [48]
5	Determining the required level of detail from BIM.	The FM team must define specific standards and guidelines for implementing and managing BIM data to ensure consistency and reliability. Establishing clear policies was critical for the effective operations and management throughout the building's lifecycle.	[11], [13], [22], [23]
6	Definition of handover and integration requirements between FM and BIM.	Defining handover and integration requirements between the FM and BIM was crucial to ensure accurate implementation and data transfer. Proper execution minimizes errors that could lead to significant operational disruptions and safety issues.	[10], [14], [24], [46],[48]
7	Identification of BIM data needs and establishment of standards/guidelines.	The FM team must understand the BIM capabilities from the outset to effectively manage and utilize the data provided. An awareness of both its limitations and potential ensures informed decision-making and enhances operational efficiency.	[25–29], [46–48]
8	Interoperability issues.	Ensuring compatibility between different software tools and platforms could be challenging, leading to data silos and inefficiencies.	[8],[9], [29], [30]
9	Training, skill gaps.	Facility management teams might lack the necessary training to effectively use BIM tools, hindering implementation and data management.	[31–33]
10	Change management and resistance.	Overcoming resistance to change among stakeholders was crucial for a successful BIM adoption and integration into the existing workflows.	[15], [34]
G2. Challenges in data: data transfer, maintenance			
11	Granting access to all members of the FM team.	Granting access to all FM team members requires a careful consideration of data confidentiality. It is crucial to define access levels based on individual roles and needs to protect sensitive information while ensuring effective collaboration.	[8], [13], [15], [22], [23], [35]
12	Real-time information transfer.	Real-time data transfer from building systems to BIM poses a significant challenge that requires skilled personnel for accurate system installation. Proper expertise ensures a reliable data flow, enhancing operational efficiency and decision-making.	[9], [10], [12], [16], [22], [48]
13	Analysis and storage of BIM data.	Data interpretation and understanding present major challenges for the FM teams, as they must effectively analyze complex BIM data. Additionally, the large storage requirements necessitate adequate backup solutions to ensure data integrity and accessibility.	[14], [24], [36], [37]
14	Streamlining data for use by the FM team.	Streamlining data for the FM team involves using appropriate software to simplify complex information. This facilitates easier understanding and management, enhancing operational efficiency.	[8], [13], [15], [35]
15	Data sharing across multiple building systems.	Data sharing across multiple building systems was essential for optimizing operations in large factories. Integrating various systems enhances efficiency and enables better decision-making through comprehensive data insights.	[13], [14]
16	Obtaining relevant and accurate information.	Obtaining relevant andf accurate information was substantial for FM teams, as inaccuracies could lead to significant operational challenges. Minimizing errors and ensuring precise measurements were essential for effective facility management and decision-making.	[3], [7], [14], [23], [47]
17	Data security and privacy concerns.	Protecting sensitive information from unauthorized access and ensuring compliance with data protection regulations had significant challenges for the FM teams.	[5], [35], [10]
18	System compatibility and integration issues.	Ensuring compatibility between different software and hardware systems could create obstacles in data transfer and integration, hindering operational efficiency.	[3], [5], [12], [24]
19	Change management and user adoption.	Facilitating user adoption of new technologies and processes was crucial, as resistance to change could impede successful implementation and data utilization.	[13], [24], [38]
G3. Industry impediments in taking on, grasping BIM			
20	The operations' interoperability of BIM data across various IT systems.	Interoperability of BIM data across various IT systems was significant as it reduces the need for rework when employing BIM for different engineering purposes. This seamless integration enhances collaboration and efficiency in project execution.	[9], [13], [20], [35]
21	Implementation of comprehensive BIM management systems.	Implementing comprehensive BIM management systems was essential for providing end-users with detailed and diverse information. This accessibility enables informed decision-making and enhances overall operational efficiency.	[9], [10], [15], [17]
22	Insufficient software skills within the FM team.	Insufficient software skills within the FM team pose a significant challenge, as many facility managers lack adequate training in using the BIM software. This gap could hinder their ability to understand and effectively utilize BIM models, limiting the potential benefits of the technology.	[6], [16], [17], [22]
23	Reluctance among the FM team to embrace BIM for FM tasks.	The reluctance among the FM team to embrace BIM for FM tasks stems from their familiarity with traditional data-sharing methods. This resistance to change could hinder the adoption of new technologies, making it challenging to realize the benefits of BIM in facility management.	[2], [11]

24	Analysis and filtering of BIM data to obtain reliable information.	Analysis and filtering of BIM data was essential to ensure the reliability of information transmitted to the end users. Implementing systems that check for accuracy and remove unnecessary data helps deliver clear and concise information, enhancing the decision-making efficiency.	[1], [7], [15], [24]
25	BIM data visualization.	BIM data visualization was crucial for the FM team to interpret and simplify complex information effectively. Utilizing visualization tools could transform raw data into accessible formats, enhancing understanding and facilitating better decision-making.	[10], [13], [15], [21]
26	Real-time updates of BIM models.	Real-time updates of BIM models, following implementation, were essential to maintain accuracy, relevance. A robust mechanism must be established to allow authorized personnel to update the model seamlessly, ensuring that multiple contributors could work collaboratively without conflicts.	[18],[20], [23], [21]
27	BIM systems security.	BIM systems face vulnerabilities to cyberattacks, making robust security measures essential. Administrators must implement comprehensive security protocols to protect systems from potential breaches and ensure the integrity of sensitive data.	[35]
28	Data governance and management policies.	Establishing clear data governance policies was vital to effectively manage data quality, ownership and access across the organization.	[10], [14]
29	Integration of legacy systems.	Integrating BIM with the existing legacy systems could pose significant challenges, as compatibility issues might arise, complicating data transfer and management.	[2], [6], [7], [9], [10]
G4. Cost challenges			
30	The significant upfront cost of BIM implementation in the organization.	The significant upfront cost of BIM implementation stems from the need for skilled manpower and resources to build and integrate the system effectively. This major investment could strain budgets but was essential for long-term operational efficiency and project success.	[6], [12], [21], [39], [40], [48]
31	Uncertainty regarding (ROI).	Uncertainty regarding the Return On Investment (ROI) in BIM adoption often leads organizations to hesitate in implementation. A lack of awareness about the long-term benefits and cost savings associated with BIM could prevent companies from recognizing its value and potential for improved efficiency.	[10–12], [15]
32	Asset change or relocation management.	Asset change or relocation management poses challenges as relocating an organization or modifying the workplace could significantly increase costs. The transfer of systems and equipment requires careful planning and resources, impacting the operational efficiency and budget allocations.	[35], [47]
33	Limited owner awareness of BIM benefits and capabilities in the FM phase.	Limited owner awareness of the BIM benefits during the FM phase could hinder effective implementation, as owners might not grasp how BIM enhances efficiency and collaboration among engineers and the FM teams. This lack of understanding could result in missed opportunities for optimized building management and long-term cost savings.	[5], [15], [22]
34	Insufficient knowledge in the FM industry regarding the benefits of BIM.	Insufficient knowledge in the FM industry regarding the benefits of BIM was prevalent, as many facility managers had never used BIM in their operations. This lack of experience leaves them uncertain about BIM's advantages, potentially limiting its adoption and the optimization of facility management processes.	[13], [23]
35	Routine updates of BIM systems.	Routine updates of the BIM systems were essential to maintain smooth operation and fix bugs, necessitating ongoing efforts from the organization. This regular maintenance could slightly increase costs, but it was crucial for ensuring the reliability and effectiveness of the BIM infrastructure.	[6], [12], [16]
36	Designated costs for training FM personnel.	The designated costs for training the FM personnel were crucial when implementing a BIM system, as effective training ensures that the team could proficiently use the program and understand the data. Investing in regular training reduces future errors and minimizes the need for extensive supervision, ultimately enhancing operational efficiency.	[3], [6]
37	Hidden costs of customization and integration.	Customizing BIM solutions to fit specific organizational needs and integrating them with the existing systems could lead to unforeseen expenses, complicating budget management.	[6], [12], [41]
G5. Challenges in overseeing lawful, contractual risks in BIM-FM integration			
38	Management of confidential information within the organization.	The management of confidential information within the organization was critical, as contract documents were often sealed, signed, and were accessible only to authorized personnel. A data leak could occur if these sensitive documents stored in a BIM system were compromised, highlighting the need for robust security measures to protect the organization against unauthorized access.	[6], [12], [41]
39	Absence of legal regulations regarding BIM use in the FM industry.	The absence of legal regulations regarding BIM use in the FM industry creates ambiguity around data ownership and copyright issues. This lack of clarity could lead to disputes and challenges in managing rights and responsibilities, potentially complicating BIM implementation and usage.	[6], [7], [14], [42]
40	Establishing handover requirements in the contract for FM tasks.	Establishing clear handover requirements in the contract for FM tasks was essential in facilitating effective BIM management post-handover. A well-defined framework ensures that all necessary information and responsibilities were transferred smoothly, enabling facility managers to utilize BIM effectively from the outset.	[7], [10], [15], [22]
41	Inadequate data encryption and security measures.	Insufficient encryption and security protocols could leave sensitive information vulnerable to unauthorized access, increasing the risk of data breaches.	[18]
42	Lack of employee training on data confidentiality.	Without adequate training on handling confidential information and understanding the implications of data leaks, employees might inadvertently compromise sensitive data.	[4], [7], [18]

IV. FINDINGS

A. Demographic Characteristics of the Respondents

The demographic data collected for 52 individuals engaged in the field of FM provides insight into their roles and the duration of their experience in construction and industry. As presented in Table III, the majority of the participants, representing 60% of the total sample, occupy the role of facility manager. Additionally, Table III shows the number of employees who are directly responsible for overseeing the overall impact of the facilities. In contrast, 16% of the participants are BIM managers, who specialize in integrating BIM into policy management practices and are also interested in integrating BIM into FM practices. Moreover, 15% of the participants occupy the role of CEO, while the remaining 9% are of a different managerial designation, reflecting a diversity of professional and managerial responsibilities. An analysis of

the participants' professional backgrounds reveals a diverse range of experiences. In particular, 17% of the respondents have over 20 years of experience, which is indicative of a substantial depth of knowledge and expertise in the field. Meanwhile, 31% have 10-15 years of experience, which provides a solid foundation in the FM practices.

TABLE II. THE ADOPTED WEIGHTING AND SCALE OF INTERPRETATION FOR EACH CHALLENGING RATING

Challenging rating	Weight (a_i)	Scale (%)
EE (x_0)	4	87.5–100
StE (x_1)	3	62.5–87.5
ME (x_2)	2	37.5–62.5
SlE (x_3)	1	12.5–37.5
NE (x_4)	0	0–12.5

A further 34% of the respondents have between five and 10 years of experience, indicating that they have undergone a certain degree of professional development in their roles. Additionally, 18% of the respondents have less than five years of experience, bringing novel perspectives to the industry. Table III provides a detailed account of the types of facilities managed by these professionals. Among the facility managers, 48% manage commercial facilities, which serves to presenting the considerable prevalence of this sector within their portfolios. A noteworthy proportion of their management experience, 23%, is dedicated to educational facilities, reflecting the crucial role of maintaining optimal learning environments. Additionally, 29% of their experience is concentrated in residential facilities, underscoring a significant involvement in housing and living spaces. This emphasis on the specific nature of this area is a notable aspect of their professional background. In sum, the prominence of commercial facilities in the profiles of all respondents highlights their pivotal role within the FM field. These facilities frequently necessitate intricate management procedures and operational oversight, underscoring the critical importance of their inclusion in the profiles.

TABLE III. JOB TITLES OF RESPONDENTS, YEARS OF EXPERIENCE, TYPES OF MANAGED FACILITIES

Respondents	Percentage (%)	1–5 years (%)	6–10 years (%)	10–15 years (%)	More 20 years (%)	Type of managed facilities		
						Commercial (%)	Educational (%)	Housing (%)
FM	60	15	16	23	6	48	48	29
BIM Managers	16	0	16	0	0	40	40	32
Director/CEO	15	0	0	6	9	63	63	35
Other Managers	9	3	2	2	2	40	40	30
Total	100	18	34	31	17			

B. Influence of the Identified Challenges on the BIM Use in FM

As shown in Table IV and Figures 1 and 2, the evaluation results demonstrate that all studied and identified challenges were classified as having a strong severity index, with the exception of one challenge that exhibited an even more severe effect. The three most significant challenges, as determined by their impact, are: the definition of handover and integration requirements between the FM and BIM challenge was identified as the most effective, with an EI of 88.33%. This was followed by the identification of key items that can be managed by BIM, with an EI of 86.01%, and the determination of the required level of detail from BIM, with an EI of 84.68%. In contrast, the challenges with the least impact include the absence of legal regulations regarding BIM use in the FM industry, with an EI of 74.0%, the asset change or relocation management, with an EI of 73.2%, and the uncertainty regarding the return on initial investment in BIM adoption, with an EI of 72.83%. The authors of the present study align with the findings and strongly advocate for the conclusion that the pervasive adoption of BIM in the FM industry in Egypt has been impeded. This is primarily due to a lack of awareness among AEC/FM stakeholders regarding the potential benefits of BIM implementation. This ignorance perpetuates the challenges identified in this review, which span several areas, including BIM implementation in FM, data management, technology, interoperability, cost, and legal and contractual issues.

C. Challenges Related to BIM Implementation in FM

The outcomes displayed in Table IV demonstrate that these challenges have a significant impact on the evaluated group, with one challenge being identified as having a particularly severe impact. The challenge exhibiting the highest value of EI was the definition of handover and coordination requirements between the FM and BIM, with a score of 88.33%. The second highest value was observed for the identification of key items manageable by BIM, with an EI of 86.01%. Finally, the identification of the BIM data needs and establishment of standards/guidelines demonstrated an EI of 82.67%, whereas the mean value of the EI for this group is 84.42%.

D. Challenges in Information Management during Data Transfer and Maintenance

The primary challenges within this category include BIM system security, with an EI of 73.18%, implementation of comprehensive BIM management systems, with an EI of 80.27%, and analysis and filtering of BIM data to obtain reliable information, with an EI of 79.6%. Each of the eight challenges within this category was determined to have a significant and profound impact, while the mean value of the EI for this category is 75.44%.

E. Technological Obstacles in Adopting and understanding BIM

The primary challenges within this category include the BIM system security, with an EI of 73.18%, the implementation of comprehensive BIM management systems, with an EI of 80.27%, and the analysis and filtering of BIM data to obtain reliable information, with an EI of 79.6%. Each of the eight challenges within this category was evaluated as having a significant and profound impact, with an average EI value of 78.31%.

TABLE IV. EI OF THE CHALLENGES OF USING BIM IN FM

No.	Challenges statements	EI	EL	IR	OR	References
	G1: Challenges related to BIM implementation in FM					
1	Allocation of BIM data ownership in the pre-design phase.	79.67	SE	10	19	[4][5], [6]
2	Identification of key elements managed by BIM.	82.83	SE	6	9	[5], [7–9]
3	Identification of the level of detail needed from BIM.	80.31	SE	9	17	[4], [9], [10] , [11], [12]
4	Identification of key items manageable by BIM.	86.01	SE	2	2	[10], [13]
5	Determining the required level of detail from BIM.	84.67	SE	4	5	[1], [13], [14]
6	Definition of handover and mix prerequisites among FM and BIM.	88.33	EE	1	1	[4], [8], [15]
7	Identification of BIM data needs and establishment of standards/guidelines.	82.67	SE	7	10	[16–20]
8	Interoperability issues.	81.5	SE	8	11	[8],[9], [29], [30]
9	Training, skill gaps.	85.67	SE	3	3	[24–26]
10	Change management and resistance.	84.17	SE	5	7	[27], [28]
	Average	84.42				
	G2: Challenges in information management during data transfer and maintenance					
11	Granting access to all members of the FM Team.	77.17	SE	8	22	[13], [22], [23]
12	Real-time information transfer.	83.83	SE	3	8	[4], [5], [14], [22], [31]
13	Analysis andstorage of BIM data.	84.68	SE	2	6	[8], [15], [29], [33], [34]
14	Streamlining data for use by the FM team.	80.33	SE	4	15	[13], [23], [28], [32]
15	Data sharing across multiple building systems.	85.5	SE	1	4	[8], [13]
16	Obtaining relevant and accurate information.	81.33	SE	5	13	[8], [11], [35]
17	Data security and privacy concerns.	75.18	SE	7	29	[4], [32], [36]
18	System compatibility and integration issues.	77.5	SE	6	21	[5], [11], [15], [36]
19	Change management and user adoption.	69.17	SE	9	42	[13], [15], [37]
	Average	70.63				
	G3: Technological obstacles in adopting and understanding BIM					
20	The operations' interoperability of BIM data across various IT systems.	73.83	SE	6	32	[10], [13], [22], [32]
21	Implementation of comprehensive BIM management systems.	80.27	SE	1	16	[4], [22], [28], [38]
22	Insufficient software skills within the FM team.	75.17	SE	5	30	[6], [14], [31], [38]
23	Reluctance among the FM team to embrace BIM for FM tasks.	75.83	SE	4	27	[1], [7]
24	Analysis and filtering of BIM data to obtain reliable information.	78.33	SE	2	20	[15], [28], [30]], [35]
25	BIM data visualization.	76.67	SE	3	23	[4], [12], [13], [28]
26	Real-time updates of BIM models.	73.12	SE	8	37	[12], [18],[20], [23],
27	BIM system security.	73.18	SE	7	36	[32]
28	Data governance and management policies.	70.33	SE	9	40	[4], [8]
29	Integration of legacy systems.	70.29	SE	10	41	[4], [6], [7], [22], [35]
	Average	78.31				
	G4: Cost challenges					
30	The significant upfront cost of BIM implementation in the organization.	76.41	SE	2	25	[5], [6], [12], [40], [41]
31	Uncertainty regarding the return on initial investment in BIM adoption.	72.83	SE	6	38	[1], [4], [5], [28]
32	Asset change or relocation management.	73.2	SE	5	35	[32]
33	Limited owner awareness of the BIM benefits and capabilities in the FM phase.	81.4	SE	1	12	[14],[28], [36]
34	Lack of knowledge in the FM industry regarding the benefits of BIM.	76.42	SE	8	24	[13]
35	Routine updates of BIM systems.	75.5	SE	4	28	[5], [6], [31]
36	Designated costs for training the FM personnel.	76.3	SE	3	26	[6], [11]
37	Hidden costs of customization and integration.	71.88	SE	7	39	[5], [6], [42]
	Average	75.44				
	G5: Challenges in Managing Legal and Contractual Risks in B.I.M-FM Integration					
38	Management of confidential information within the organization.	79.83	SE	2	18	[5], [6], [42]
39	Absence of legal regulations regarding BIM use in the FM industry.	74.0	SE	3	31	[6], [8],[43], [35]
40	Establishing handover requirements in the contract for FM tasks.	81.17	SE	1	14	[4], [14], [28], [35]
41	Inadequate data encryption and security measures.	73.5	SE	4	33	[39]
42	Lack of employee training on data confidentiality.	73.43	SE	5	34	[9], [35], [39]
	Average	76.59				

F. Cost Challenges

This category includes eight challenges, with limited owner awareness of the BIM benefits and capabilities in the FM sector, exhibiting the highest EI at 81.4%. The second challenge was identified as the lack of knowledge in the FM industry regarding the advantages of BIM. This challenge exhibited an EI of 76.42%. The third most significant challenge was the regular updating of BIM systems, with an EI of 75.5%, with the mean value EI for this category being 75.44%.

G. Legal and Contractual Challenges

Each of the five challenges in this group has a significant impact. he remaining three challenges, namely establishing handover requirements in the contract for the FM projects, the management of confidential information within the

organization, and absence of legal regulations regarding BIM use in the FM industry, have EIs of 81.17%, 79.83%, and 74.0%, respectively. The mean value of EI for this group is 76.59%.

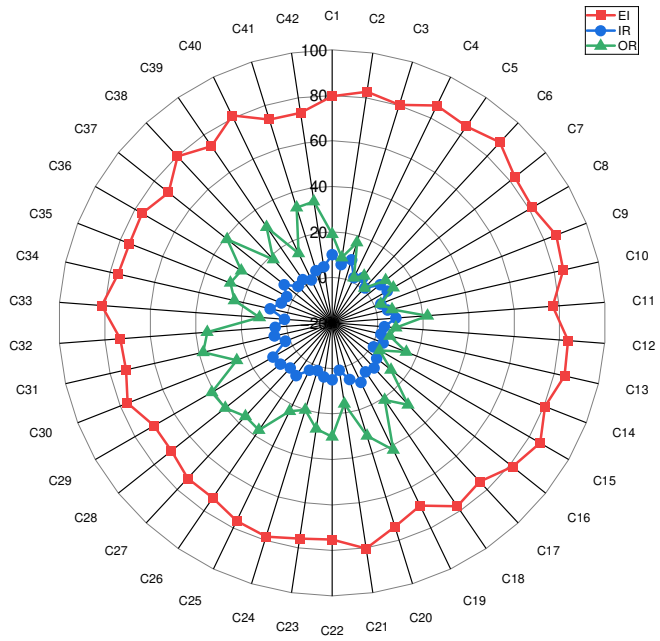

Fig. 1. Evaluation of BIM challenges (C1 to C42).

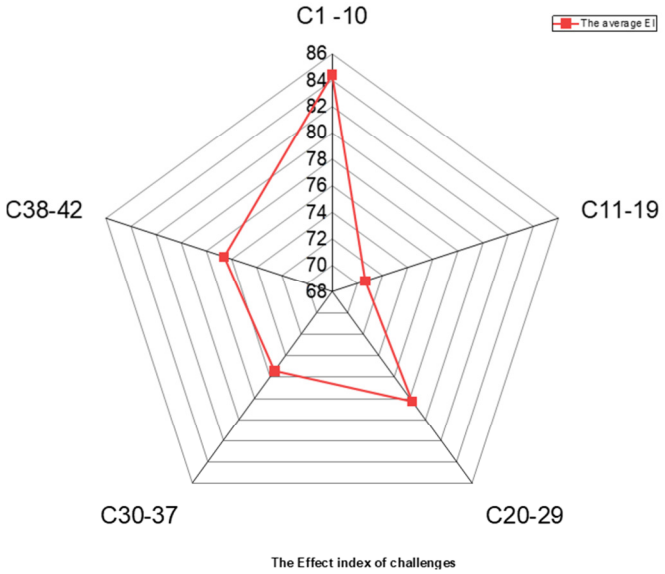

Fig. 2. The main average evaluation of the main five groups of the BIM Challenges (G1 to G5).

BIM has made considerable progress in developing countries, such as Egypt, despite the increase in awareness of its potential advantages. It enables facility managers to engage during the design phase, influencing the outcome of the built environment and leading to enhanced results and an improved FM profile.

The dataset included in the BIM comprises a comprehensive array of information, involving schedules, plans, and asset-related data, such as cost, location, lifespan, carbon emissions, maintenance details, parts, reorder information, substitutions, serial numbers, and warranty information. A better understanding of the obstacles hindering the implementation of BIM in FM could facilitate its broader application in this field. A review of the literature reveals that while numerous studies have examined BIM for FM in general, there is a paucity of research focused on the challenges associated with BIM implementation in FM, particularly in Egypt. This study identified and assessed 42 challenges regarding BIM implementation in FM, derived from an analysis of the existing literature. The research methodology involved the creation and distribution of survey questionnaires to professionals working within the FM industry in Egypt. The reliability of the findings is supported by the participants' expertise, with 60% of them having over 10 years of professional experience and 17% having over 20 years of experience. The study's findings reveal three principal challenges: the identification of handover and integration requirements between the FM and BIM, the identification of key items manageable by BIM, and the analysis and management of BIM data challenges, with EI values of 88.33%, 86.01%, and 84.68%, respectively. The aforementioned challenges were classified into five principal categories, with the primary category being that pertaining to the implementation of BIM in FM, which exhibited an average EI of 84.42%.

It has been observed that the integration of BIM within FM presents a significant challenge, as FM professionals perceive BIM to be complex, costly, and lacking in substantial return on investment. Consequently, the BIM advancement is contingent upon three key factors: firstly, the enhancement of practitioners' awareness, secondly, the provision of training programs that are focused on BIM, including implementation strategies and software, and thirdly, the establishment of robust government policies. These findings are consistent with those of previous research [20, 22, 46], which identified the lack of operational procedures for updating the design model with embedded data as a prevalent challenge in FM. Additionally, these studies underscored that the definition of the handover and integration requirements between the FM and BIM, represents a substantial hurdle, with an EI of 88.33%. The authors identified that the employed methodologies for BIM implementation, in conjunction with inaccurate or misinterpreted information, present a considerable obstacle to the adoption of BIM in the FM sector in Vietnam. The present study reaffirms these findings and highlights the challenges associated with the implementation of BIM in FM, particularly with regard to data accuracy. The findings underscore the crucial role of fostering enhanced comprehension and insight among industry stakeholders through targeted training at tertiary education institutions and ongoing professional development programs. Although this study offers valuable insights, its findings may be limited by the regional context and the specific population involved. Overall, the literature review

provides insights into potential difficulties in BIM adoption in FM, and the assessment by FM professionals highlights the most urgent challenges in Egypt. Furthermore, this study establishes a foundation for additional research in similar countries facing comparable challenges.

V. CONCLUSIONS

The Architecture, Engineering, Construction, and Facilities Management (AEC/FM) sector has undergone significant transformation as a consequence of the advent of the 4th industrial revolution. Advancements, such as the Building Information Modeling (BIM) have emerged as indispensable instruments for optimizing the life cycle management of facilities. Nevertheless, despite the perceived advantages of BIM, it remains insufficiently used in various regions, including Egypt. This research project aimed to define, clarify, and assess the challenges preventing BIM implementation in the Egyptian Facilities Management (FM) industry. This was done in response to the rising demand for sustainable facility management in the context of rapid development. The research addressed pivotal inquiries concerning the impediments to BIM adoption, their consequences on implementation, the discrepancies between large-scale and small-scale FM projects, and strategies for surmounting these challenges. The findings indicated that significant impediments to the adoption of BIM include a deficiency in knowledge and awareness regarding the advantages of BIM and the strategies for its implementation. Moreover, the study highlighted the challenges associated with the management of BIM data and the alignment of the design models with the built data. This paper provides an in-depth analysis of the significance of these challenges, offering a comprehensive overview of the optimal solutions and the most crucial practices. The establishment of comprehensive principles and strategies for the utilization of BIM will prove advantageous to a diverse range of stakeholders, including decision-makers, facility management designers, executives, managers, and policy makers. Moreover, the implementation of more robust training programs within higher education institutions will facilitate continuous professional development, thereby increasing the pool of knowledge and awareness among industry professionals. Ultimately, this research, through the presentation of previous studies and a review of the challenges facing the application of BIM in Egypt, offers practical insights that can significantly facilitate the successful application of BIM in the construction and FM sectors. By addressing these challenges, stakeholders can more effectively leverage the potential of BIM, which will in turn lead to improved facility management practices and more beneficial outcomes.

The following recommendations are proposed to facilitate a more successful BIM adoption in the FM sector in Egypt:

- It is recommended that tailored training programs be developed and implemented, with a specific focus on BIM technologies and their benefits, for professionals in the FM sector. It would be beneficial to collaborate with educational institutions to integrate BIM-related courses into their curricula and provide ongoing professional development workshops.
- Furthermore, it would be advantageous to implement awareness campaigns. It is recommended that educational workshops be conducted for stakeholders in the AEC/FM sectors, with the objective of informing them of the BIM benefits. These workshops and courses should focus on educating stakeholders about the expected benefits, as well as providing case studies on how to successfully implement BIM-related strategies.

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