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ИНТЕГРИРОВАННАЯ С BIM ПЛАТФОРМА ДЛЯ ПОДДЕРЖКИ УПРАВЛЕНИЯ ЭКСПЛУАТАЦИЕЙ И ТЕХНИЧЕСКИМ ОБСЛУЖИВАНИЕМ УЧЕБНЫХ ЗДАНИЙ: ТЕМАТИЧЕСКОЕ ИССЛЕДОВАНИЕ ИЗ РАЗВИВАЮЩИХСЯ СТРАН

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АННОТАЦИЯ

Введение. На протяжении десятилетий фаза эксплуатации и технического обслуживания объектов оставалась наиболее продолжительной, дорогостоящей и ресурсоёмкой. Особенно остро эта проблема проявляется в развивающихся странах, где по-прежнему применяются традиционные подходы, характеризующиеся отсутствием современных технологий управления ресурсами и использованием устаревших эксплуатационных процессов, связанных с высоким энергопотреблением. Образовательные объекты, такие как школы и университеты, требуют эффективной организации эксплуатации и технического обслуживания вследствие их постоянного общественного использования и важной роли в развитии местных сообществ. Однако для традиционного управления эксплуатацией зданий в развивающихся странах, включая Ирак, характерны фрагментация информационных потоков, отсутствие профилактического обслуживания и ненадлежащее управление данными об активах. Информационное моделирование зданий (ИМЗ), основанное на структурированных данных, визуализации и интеграции с компьютеризованными системами управления техническим обслуживанием, обладает значительным потенциалом для совершенствования процессов эксплуатации и технического обслуживания.

Материалы и методы. В исследовании предлагается структура рабочего процесса на основе информационного моделирования зданий для управления объектами образовательной инфраструктуры в развивающихся странах. В рамках тематического исследования анализируется существующий процесс управления объектами в типичной школе города Эль-Кут, расположенного в центральной части Ирака. В исследовании выявляются основные препятствия и разрабатывается рабочий процесс применения информационного моделирования зданий на этапе управления объектами, объединяющий строительный контроль, обмен информацией о здании, цифровое формирование и выполнение заявок на работы, а также планирование профилактического технического обслуживания.

Полученные результаты демонстрируют, что применение информационного моделирования зданий в системе управления объектами повышает доступность данных и улучшает взаимодействие между заинтересованными сторонами. Вместе с тем оно выявляет ряд ограничений, включая высокие затраты на внедрение, нехватку квалифицированных кадров и недостаточно развитую цифровую инфраструктуру. В исследовании предлагается новая методология, применимая в государственных образовательных учреждениях регионов с ограниченными ресурсами. Эта методология создаёт основу для внедрения устойчивых практик управления образовательными объектами.

Заключение. В исследовании делается вывод о том, что внедрение информационного моделирования зданий в систему управления объектами в развивающихся странах способно повысить операционную эффективность и надёжность активов. Однако его реализации препятствуют такие факторы, как нехватка квалифицированного персонала, отсутствие стандартов информационного моделирования зданий и высокие первоначальные затраты на внедрение.

Несмотря на эти ограничения, предлагаемая система представляет собой структурированный подход к интеграции информационного моделирования зданий в управление объектами с целью повышения устойчивости образовательной инфраструктуры. В будущих исследованиях необходимо расширить выборку за счёт включения нескольких образовательных учреждений и проанализировать долгосрочное соотношение затрат и выгод.

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КЛЮЧЕВЫЕ СЛОВА: информационное моделирование зданий, управление объектами, эксплуатация и техническое обслуживание зданий, образовательная инфраструктура, профилактическое техническое обслуживание, развивающаяся страна, Ирак

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BIM-INTEGRATED FRAMEWORK IN SUPPORT OF OPERATION AND MAINTENANCE MANAGEMENT OF EDUCATIONAL BUILDINGS: A CASE STUDY FROM DEVELOPING COUNTRIES

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ABSTRACT

Introduction. For decades, operation and maintenance has been the longest, most costly, and most resource-intensive phase of a project, especially in developing countries where traditional practices are still in place, which include a lack of modern resource management technologies and a reliance on antiquated operating systems that use a lot of energy. Educational projects like schools and universities require effective operation and maintenance processes due to their continuous public usage and importance for community development. However, traditional facility management in developing countries like Iraq is characterized by fragmented information flows, insufficient preventative maintenance, and poor asset data management. Through the use of organized data, visualization, and links to computerized maintenance management systems (CMMS), Building Information Modeling (BIM) has shown potential for improving operation and maintenance practices.

Materials and Methods. This paper proposes a Building Information Modeling-Facility Management (BIM-FM) workflow framework within the context of educational infrastructure in developing countries. Adopting a case study approach, the study analyzes the existing FM process in a typical school in Kut city, central Iraq, highlights obstacles, and develops a BIM-FM workflow that integrates Construction Operations Building information exchange (COBie), digital work orders, and preventive maintenance planning.

The findings demonstrate that the BIM-enabled FM framework improves data availability and stakeholder collaboration, while also revealing limitations such as high implementation costs, lack of skilled labor, and insufficient digital infrastructure. The study proposes a novel methodology that can be applied to public educational facilities in resource-constrained environments, laying the groundwork for sustainable school management practices.

Conclusion. The study argues that a BIM-FM workflow during the operational phase of educational buildings in developing countries can enhance operational efficiency and asset dependability; nevertheless, its implementation is hindered by challenges including a shortage of qualified staff, a lack of BIM standards and high early expenses for operations and maintenance. Notwithstanding these limitations, the framework provides a structured approach for incorporating BIM into FM to increase the sustainability of educational infrastructure. Future research should expand the scope to include several schools and analyze the long-term cost-benefit implications.

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KEYWORDS: *facility management, operation and maintenance management, educational buildings, developing country, Iraq, preventive maintenance, building information modeling*

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INTRODUCTION

Facility management (FM) encompasses planning, implementing and managing the operational stage of a constructed asset's lifecycle, emphasizing maintenance, space management, risk evaluation, and sustainability [1]. It is essential for improving organizational efficiency and successfully resolving prevalent maintenance challenges and defects [2][3]. FM still faces significant challenges related to information management issues. As a result, effective digital tools for the systematic storage, centralizing, retrieval, and continuous updating of data from the building phase must be developed [4][5]. Currently, a significant portion of building maintenance data is still recorded in paper-based formats, consisting of manuals, technical documents, and 2D drawings. Furthermore, this critical information is frequently provided to the facility owner several months after the commencement of the facility's operational phase [6]. To conduct inspections and maintenance effectively, FM personnel require access to geo-spatial data that enables the precise localization of building components during regular technical inspections and maintenance [7]. Nevertheless, FM technicians frequently encounter difficulties when attempting to reference traditional two-dimensional computer-aided design-based on-site information, which consequently results in inefficient allocation of personnel resources [8]. For building information modeling (BIM), data must be precise, current, and tailored to the FM team's needs. The data is expected to be continuously collected, preserved, and utilized throughout the entire life cycle. In a traditional approach, the main contractor delivers all asset information to the customer only upon construction completion [9].

Ariffin (2023) asserts that a comprehensive strategy is crucial for planning and running facilities [9]. This entails having a carefully considered strategy for both building construction and current administration. The information derived from

building assets is essential for regular operations controlled via specialized FM tools. Integrating this crucial information into the building model would eliminate the need for different asset management systems. Consequently, users could obtain all relevant data from one database, simplifying facility operations and enhancing operational efficiency.

The novelty of this study lies in extending BIM implementation from the design and construction stages to the operation and maintenance stage in the construction sectors of the developing countries. The research fills a significant gap in both academia and industry practice. Countries such as Iraq still rely heavily on paper-based and traditional methods of facility management techniques. The proposed Building Information Modeling-Facility Management) BIM-FM(architecture offers an efficient way to integrate digital building information into maintenance and operation procedures.

This paper presents a case study, delineating its contextual framework and the prevailing conditions of conventional FM processes. The study introduces BIM-FM workflow, meticulously designed for the systematic acquisition and representation of FM data. This methodology is predicated upon leveraging BIM functionalities and adhering to Lean principles, thereby providing robust support for the comprehensive FM domain. Furthermore, a comparative analysis evaluates the performance of the proposed BIM-FM framework against traditional FM practices. Finally, the paper outlines the challenges encountered during the case study and discusses its conclusions.

LITERATURE REVIEW

Once design and construction stakeholders hand over a building, FM is deployed to oversee and administer the asset, thereby delivering sustained value to the client for an extended period subsequent to its handover [10][11]. BIM is recognized as a pivotal element in enhancing the efficacy of decision-making processes throughout

the entire building lifespan [12], thereby mitigating unnecessary costs and preventing redundant rework within a cooperative operational paradigm [13].

Carbonari [14] developed a framework based on two distinct case studies, demonstrating that the graphical component in BIM-FM implementation for existing structures should be minimized. Instead, the primary emphasis, as concluded, should be directed towards the precise identification of crucial data required for the construction of comprehensive whole-life models.

From initial conceptualization to the completion of building operations, automated frameworks were utilized to expedite the creation of as-built BIMs, which incorporate onsite alterations made by contractors to the original design [15]. Accurate incorporation of BIM data into a CMMS is significant to optimizing its utilization throughout the FM stage. This ensures that static information is converted into dynamic inputs that raise the standard of technological operation and maintenance efficiency.

By providing a framework for collecting and exporting necessary asset data while ensuring information integrity, the COBie standard bridges the gap between design and implementation data and facility operations needs [4][16]. Integrating COBie data with various CMMS allows infrastructure managers easily access elements and their characteristics [17]. International data standards such as COBie, which facilitate collection and recording of important data, must be followed at the beginning of projects [18]. In order to obtain data relevant to operations and maintenance, facility managers are expected to be involved at an early stage of the project [19][20].

MATERIALS AND METHODS

In this paper, a case study approach was used to assess the effectiveness of BIM-supported processes in improving maintenance and operations at an educational facility in a developing country. This methodology is suitable for evaluating contemporary FM techniques in their actual operational environment, particularly when the boundaries between the phenomenon and its context are not clearly defined. In developing countries, such as Iraq, digital transformation is still in its early phases, and many public facilities – including educational buildings – continue to rely on traditional, paper-based FM procedures. The case study approach enables a more thorough analysis of the real-world challenges encountered during the operations and maintenance (O&M) stage, alongside an assessment of the prospec-

tive enhancements offered by a BIM-driven workflow.

The chosen case study focuses on a typical public-school building that represents the current state of educational infrastructure in Iraq. There were several maintenance issues within the school facility. Most of them were repaired or replaced during its operational phase by following a corrective maintenance approach, without the application of a preventive maintenance plan and standard operating procedures. The FM staff established tasks, carried them out using paper-based documentation, and kept the ensuing reports in either physical or electronic files as part of a traditional preventive maintenance workflow. As a result, when issues emerged, a significant time was lost searching for manuals, previous maintenance documents, or equipment details.

The study utilized observations, interviews with employees, and documentation evaluation to record the current FM procedure in order to identify this issue. Following this, the existing situation was mapped into a workflow diagram that shows how maintenance tasks are initiated, monitored, executed, and stored under the conventional system.

A BIM-enabled FM process was developed to address the limitations identified during the diagnostics. Two primary inputs that shaped the workflow were (A) a BIM dataset that included all essential school systems and equipment, and (B) asset data that was collected and arranged using the COBie framework. These inputs served as the foundation for a digital FM platform capable of centralizing data, generating maintenance work orders, as well as supporting personnel in executing both preventative and corrective maintenance tasks.

To ensure continuous information flow and minimize inefficiencies, the BIM-FM workflow was developed by aligning BIM functionality with FM requirements and Lean principles. While the COBie database enabled centralization and retrieval of equipment attributes, historical maintenance data, warranties, and maintenance tasks, the BIM model was utilized for visual identification of building elements. Consequently, the traditional reporting system was replaced with a computerized work order framework designed to streamline maintenance operations.

Finally, a process for data sharing was established to define the data exchange mechanism among the FM platform, COBie spreadsheets, and the BIM model. Preparing BIM parameters within authoring tools, setting up spaces and equipment locations, populating asset attributes,

validating COBie data accuracy, and integrating the compiled information into the FM system comprised all the steps in the process. This approach made it possible to evaluate improvements in data accessibility, task execution, and information completeness by contrasting the suggested BIM-FM process with the conventional FM practices.

1.1 CASE STUDY: SCHOOL BUILDING

The selection of the existing school building for this study was driven by the observation that the maintenance of government buildings in Iraq frequently deviates from established management systems. Furthermore, facility managers in this sector face critical challenges such as aging infrastructure, suboptimal energy efficiency, and a pervasive lack of critical asset information, all of which impede effective decision-making in maintenance operations.

The building selected for the study is Al-Rabab Secondary School, located in the city center of Kut, Wasit Governorate, Iraq. The school was constructed as part of the National Program for the Construction of 1,000 Model Schools, implemented under an Iraqi-Chinese agreement by the Powerchina Company, and is owned and administered by the Iraqi Ministry of Education. The project consists of three building models (a 12-classroom model, an 18-classroom model, and a 24-classroom model). The selected case study building follows the 24-classroom model,

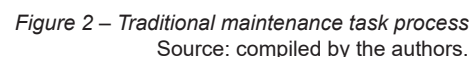
representing one of the largest educational building models within the program. The structure comprises three stories and incorporates a range of academic, administrative, and auxiliary service spaces.

The educational facility operates continuously, experiencing high daily occupancy, which consequently accelerates the wear and deterioration of its various structural and mechanical components. During the construction phase, a conventional project delivery methodology was used, lacking explicit BIM requirements for O&M lifecycle. Consequently, the documentation provided to the FM department consisted of a fragmented collection of two-dimensional architectural drawings, equipment manuals, and disparate reports. An integrated digital model or a systematically organized asset database was notably absent.

Numerous operational incidents and system malfunctions, including HVAC breakdowns, plumbing deficiencies, lighting defects, and sewer line blockages, were documented throughout the operating stage. Maintenance operations were often reactive, focusing mostly on fixing urgent issues. Due to labor constraints and budget limitations, preventive maintenance was carried out intermittently. Following each activity, technicians generated paper-based reports, shared via email or kept in physical binders. Data duplication, information gaps, and documentation inaccuracies were common consequences of this approach.



Figure 1 – A 3D Model for the case study
Source: compiled by the authors.



1.2 BIM-FM FREAMWORK METHODOLOGY PROPOSAL

```

graph TD
    PM[Preventive Maintenance Plan] --> RVT[RVT]
    DV[3D Dynamic Visualization] --> RVT
    RVT --> EFM((ecodomus FM Platform))
    EFM <--> SI[Scheduled Inspections]
    SI --> I[Inspection]
    I --> WOG[Work Order Generation and Issuing]
    WOG --> WOR[Work Order Review]
    WOR --> RWO[Replacement Works Repair Operations]
    RWO --> PF[Performance Feedback]
    PF --> C[Checklist]
    C -- Approval --> I
    C -.->|Input Data| EFM
    FM[Facility Manager] -.-> SI
    MS[Maintenance Supervisor] -.-> I
    MT[Maintenance Technician] -.-> WOR
  
```

Figure 3 – BIM-based approach to maintenance planning
Source: compiled by the authors.

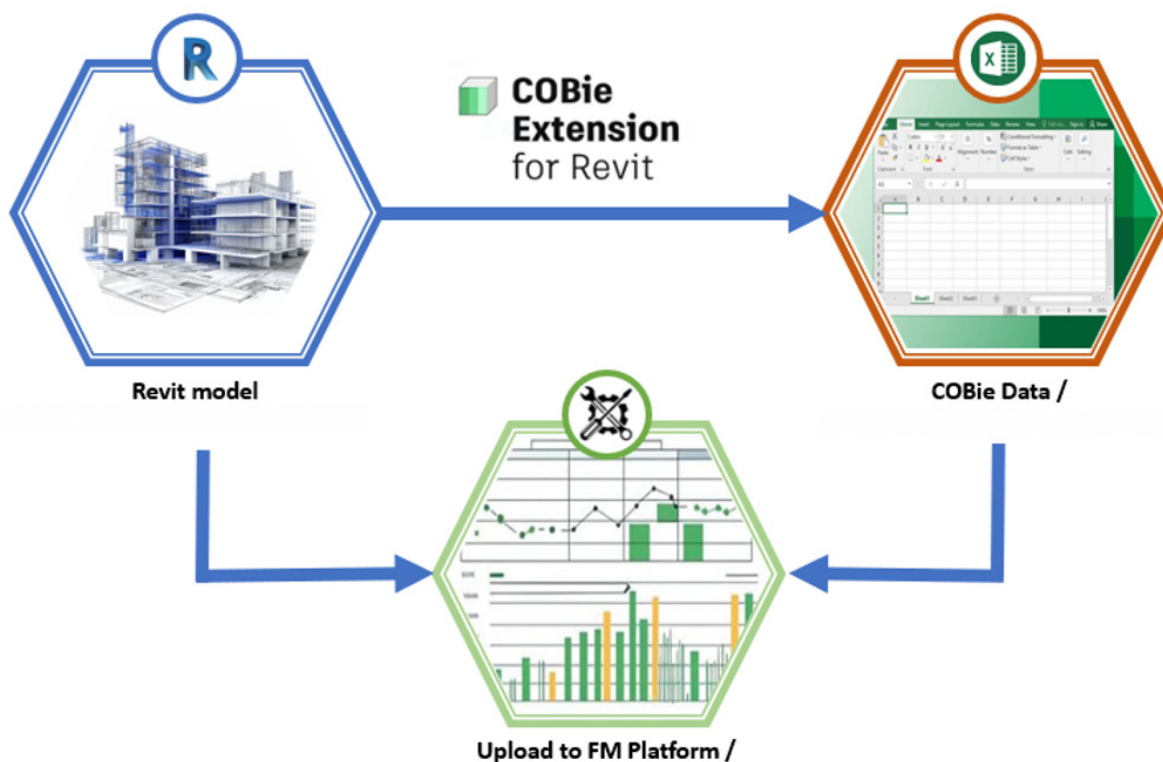


Figure 4 – Revit-to-FM platform-based data exchange process
Source: compiled by the authors.

The BIM-FM integration methodology relies on data flows from two primary sources: the COBie standard for asset information and the as-built spatial BIM model. In order to ensure operational efficiency, synchronous connectivity between these components is established, with the integrated data exported to the EcoDomus cloud-based common data environment. Given that the COBie data provides significant maintenance-related information, only minimal modifications are normally performed within Ecodomus. If it is essential to add or delete components from the as-built BIM model, a native modeling software, such as Revit, can be used for further modification and updating.

As required for information transmission, COBie format entails certain procedures to ensure

data accuracy and reliability. This approach represents spatial layout and asset identification of the project by consolidating various types of data.

The metadata in the BIM model is mapped to the COBie format via the COBie extension in Revit software. Thus, this extension exports the file as the final output after transferring data from the model elements to specific COBie attributes. The COBie extension process includes several steps, starting with project setup and defining contacts and zones, proceeding to selecting elements, maintenance data, and formatting adjustments, and concluding with final data export to a COBie Excel file via the Autodesk COBie extension. This file is of crucial importance, as it serves as the primary reference for design and construction data required for efficient FM.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
	Name	CreatedBy	CreatedOn	Category	FloorName	Description	ExtSystem	ExtObject	ExtIdentifier	RoomTag	UnblockHeight	GrassArea	MedArea			
1	Sport room	R00@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	CO A01_3	n/a	n/a	12.92			
2	Food storage	R00@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	CO A01_4	n/a	n/a	12.79			
3	Toilet	R00@yahoo.com	n/a	n/a	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	CO A01_6	n/a	n/a	20.18			
4	Toilet	R00@yahoo.com	n/a	n/a	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	CO A01_5	n/a	n/a	20.17			
5	Class	R01@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	AC A01_1	n/a	n/a	38.72			
6	Class	R01@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	AC A01_2	n/a	n/a	39			
7	Class	R01@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	AC A01_3	n/a	n/a	38.72			
8	Class	R01@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	AC A01_4	n/a	n/a	38.82			
9	Class	R01@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	AC A01_5	n/a	n/a	39.16			
10	Class	R01@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	AC A01_6	n/a	n/a	38.82			
11	Computer room	R01@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	AC A01_7	n/a	n/a	37			
12	Librarian	R01@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	AC A01_8	n/a	n/a	37			
13	Teachers room	R01@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	AD A01_1	n/a	n/a	15			
14	Teachers room	R01@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	AD A01_2	n/a	n/a	15			
15	Headmaster room	R01@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	AD A01_3	n/a	n/a	15			
16	Assistant room	R01@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	AD A01_4	n/a	n/a	11			
17	Accou. room	R01@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	AD A01_5	n/a	n/a	7			
18	Books store	R01@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	AD A01_6	n/a	n/a	11			
19	Toilet	R00@yahoo.com	n/a	n/a	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	AD A01_7	n/a	n/a	4			
20	Toilet	R00@yahoo.com	n/a	n/a	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	AD A01_8	n/a	n/a	4			
21	Toilet	R02@yahoo.com	n/a	n/a	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	CO A01_1	n/a	n/a	3			
22	Toilet	R02@yahoo.com	n/a	n/a	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	CO A01_1	n/a	n/a	3			
23	Entrance Hall	R02@yahoo.com	n/a	n/a	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	CO A01_1	n/a	n/a	38			
24	Hall	R02@yahoo.com	n/a	n/a	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	CO A01_1	n/a	n/a	140			
25	Exch. room	R02@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	CO A01_1	n/a	n/a	6			
26	Exch. room	R02@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	CO A01_1	n/a	n/a	6			
27	Bath	BR1@yaooc	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	CO A01_2	n/a	n/a	3			
28	Guard room	R00@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	CO A01_2	n/a	n/a	11			
29	ELECTRIC ROOM	R01@yahoo.com	n/a	Room	Ground Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	ftcb732a	CO A01_7	n/a	n/a	8			
30	Class	R01@yahoo.com	n/a	Room	First Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	d88c2098	AC A02_1	n/a	n/a	39			
31	Class	R01@yahoo.com	n/a	Room	First Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	d88c2098	AC A02_2	n/a	n/a	39			
32	Class	R01@yahoo.com	n/a	Room	First Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	d88c2098	AC A02_3	n/a	n/a	39			
33	Class	R01@yahoo.com	n/a	Room	First Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	d88c2098	AC A02_4	n/a	n/a	39			
34	Class	R01@yahoo.com	n/a	Room	First Floor	n/a	Autodesk Revit 2020, Build: 20190327, 2315(x64)	lfcSpace	d88c2098	AC A02_5	n/a	n/a	39			

Figure 5 – COBie file for the school building
Source: compiled by the authors.

RESULTS AND DISCUSSION

With a set of fundamental BIM technology features tailored to the practical constraints related to educational facilities in developing countries, the suggested BIM-enabled FM framework facilitates maintenance tasks. During both preventive and corrective maintenance procedures, these features are designed to improve decision-making, reduce response times, while enhancing information accessibility.

1. Accurate Location and Identification of Building Components

One of the primary problems with traditional

maintenance procedures is locating building components, particularly those concealed in service tunnels or ceilings. Integrating the BIM model within the FM system, allows technicians to visually find assets such as HVAC equipment, valves, electrical panels, and plumbing connections. Since COBie links each component to its relevant attribute data, technicians can access equipment specifications, installation dates, and maintenance histories within the model. This functionality significantly reduces asset search time and prevents redundant site checks.

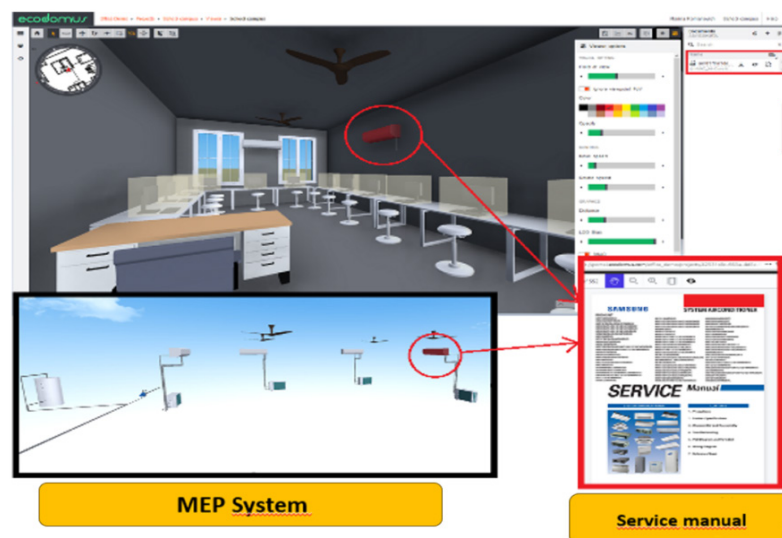


Figure 6 – Service document integration for indoor ventilation equipment via Ecodomus
Source: compiled by the authors.

2. Improved Maintainability

All activities, including preventative and corrective maintenance, must be documented using WOs as part of BIM-supported maintenance management (MM) approach. Consequently, facility managers can precisely find and diagnose issues as well as make best decisions based on real-time data. Recurrent WOs for a specific component indicate that the equipment is defective, suggesting component replacement and a review of its warranty status.

3. Prioritization and coordination of maintenance

Preventive maintenance refers to systematically performed operations on components or structures to minimize the likelihood of failure. Conducted when the equipment or component is still in service, this form of maintenance aims

to extend the lifecycle of the system or facility. Within the facility management sector, deferred maintenance severely impacts facilities and building structures, resulting in substantial long-term financial and resource losses. According to a survey by the Council of Great City Schools [14], every \$1 spent on planned maintenance saves \$5 in deferred maintenance costs.

Building maintenance is a complex and information-intensive process. The Mechanical, Electrical, and Plumbing (MEP) systems also include ventilation and fire protection systems, all of which require routine preventive maintenance. As the BIM database consolidates all the required information to enable stakeholder access to critical building information, a specialized Dynamo-based tool was developed in this study, which allows managers to define operational priorities.

Table 1

Task execution time comparison: conventional FM vs. proposed BIM-FM process per incident
Source: compiled by the authors.

Task	Conventional FM (min)	Proposed BIM-FM (min)	Time Savings (min)
Request Submission	10	3	7
Problem Identification	45	5	40
Information Search	25	5	20
Task Execution	T	T	T
Data Registration	20	10	10
Total	100+T	23+T	77+T

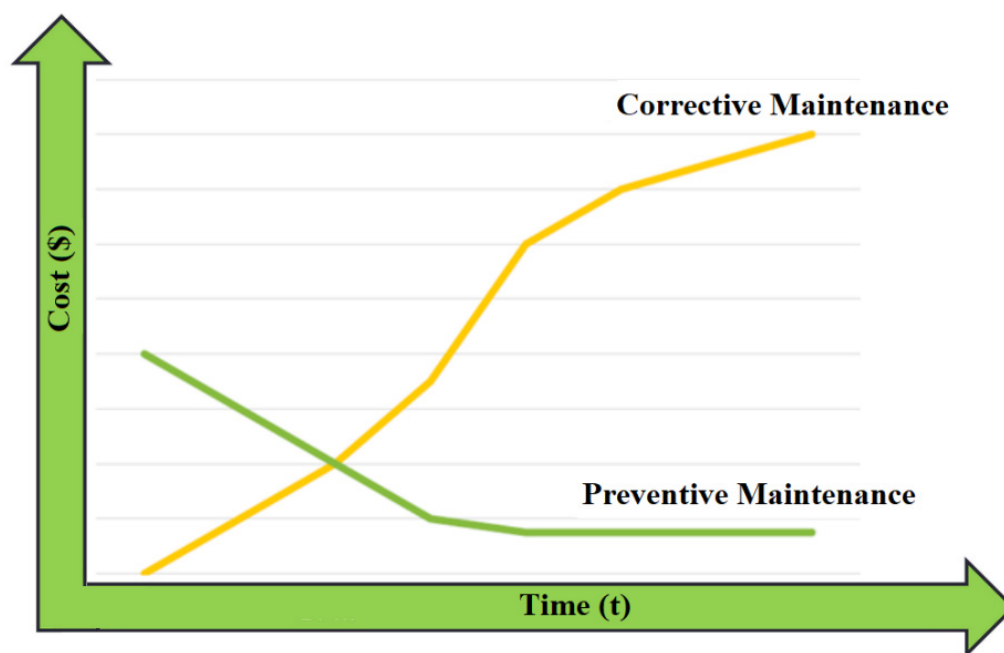


Figure 7 – Corrective maintenance vs. preventive maintenance
Source: compiled by the authors.

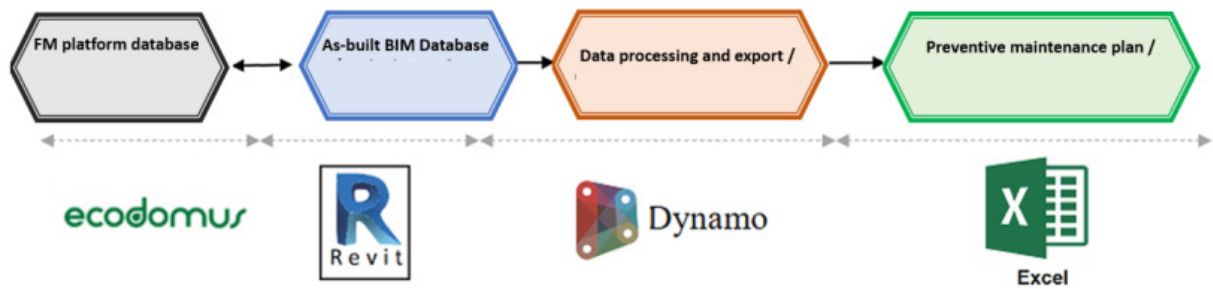


Figure 8 – Exporting priorities for maintenance (preventive maintenance)
Source: compiled by the authors.

4. Dynamic visualization for preventive maintenance

BIM can be integrated with advanced modeling and scheduling software to optimize maintenance workflows. As a result, BIM facilitates 4D sequencing operations.

The use of advanced modeling software for generating procedural animations significantly improves planning through advanced visualization. This approach allows users to generate high-definition renderings and animations, as well as visu-

alize complex data within a virtual environment.

The suggested approach focuses on using 3D visualization to link component maintenance plans, thus simplifying maintenance priority determination. It involves color-coding of facility elements within the project's 3D or 2D views to reflect their current maintenance state.

Based on Revit database and maintenance schedules, a script was developed in Dynamo and Python. The script principle is illustrated in figure 9.

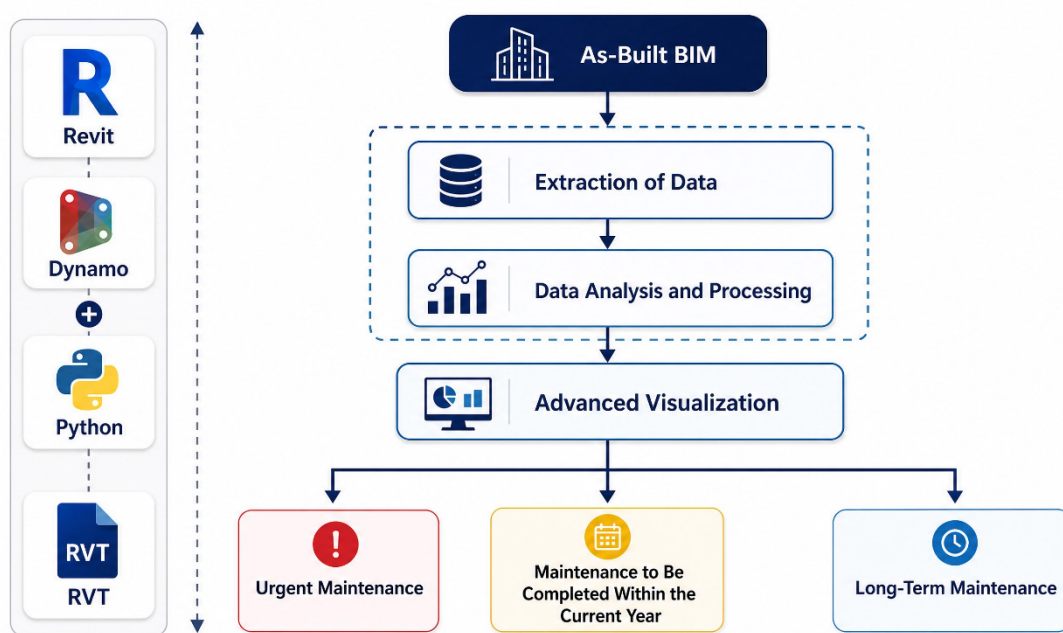


Figure 9 – BIM-based advanced maintenance visualization process
Source: compiled by the authors.

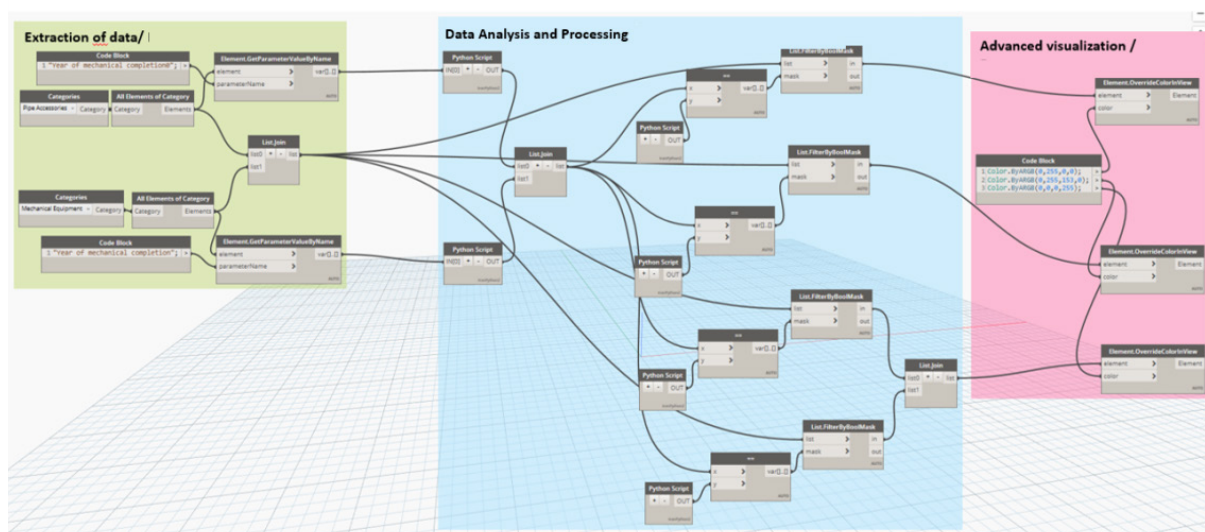


Figure 10 – Dynamo graph for 3D maintenance visualization
Source: compiled by the authors.

In Dynamo, the maintenance control parameters are extracted along with the planned preventive maintenance dates. The Python script is used to process the data and assign a specific color to each component based on the maintenance schedule. Three scenarios are examined:

- Red: highlights components requiring urgent maintenance;
- Yellow: highlights components requiring within-year maintenance;
- Blue: highlights components requiring future (long-term) maintenance.

Revit 2025 is utilized to generate the visualization. The details for the script developed are shown in Figure 10.

The 3D visualization of the scheduled 2025 maintenance for the school building's water pump shows that the water pump component within the BIM model is highlighted in yellow to alert the operator to required repairs during the current year (Figure 11A). If the maintenance is not performed by the deadline, the system displays the element in red, as illustrated in Figure 11B. Regular maintenance is essential to prevent water pump failure. Figure 11C shows the water pump in blue, indicating that correct maintenance was completed and documented in the system.

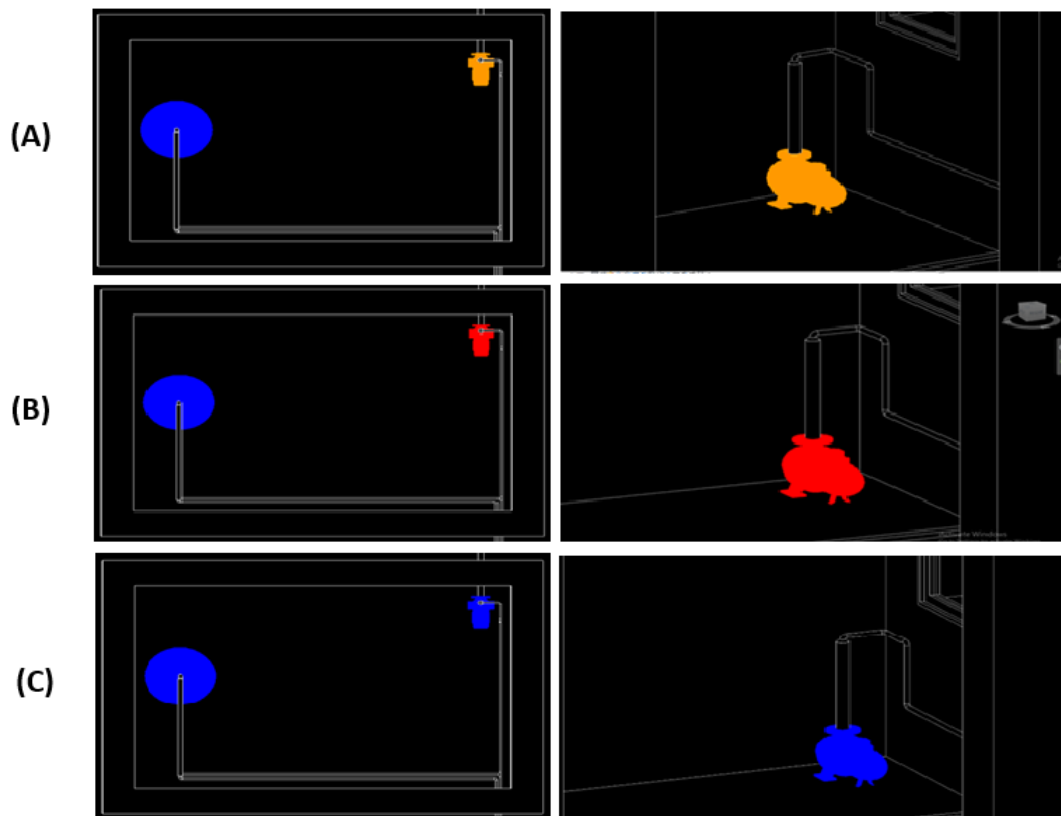


Figure 11 – 3D visualization results for the school building water pump maintenance
Source: compiled by the authors.

5. Recommendations for Addressing Challenges in BIM Adoption for MM

There are several barriers in adopting BIM technology for FM and MM within the public and private construction sector in Iraq. They are related to technology, people, and management, as detailed below.

Technology-related challenges. The shortage of tools and new hardware compatible with these programs directly impedes BIM adoption. The absence of technical support from top management and government in training engineers on BIM tools delays further integration of BM technology in construction sector. To address this issue, top management and government should offer suitable BIM software and hardware as well as adequate technical support.

People-related challenges. Adopting 6D BIM in construction projects requires qualified managers and staff proficient in BIM tools. In Iraq, facility managers and personnel often lack experience to operate sophisticated software and hardware.

Management-related challenges. Top management plays a significant role in driving BIM adoption within government projects by encouraging stakeholders to utilize BIM and supporting managers in upgrading their skills in this field. Furthermore, government should secure financial resources to provide the necessary tools and hardware, while also offering training courses to improve staff proficiency in this area.

CONCLUSIONS

This study presented a BIM-enabled FM framework tailored to the operational requirements of school buildings in developing countries. By analyzing traditional maintenance workflow and comparing it with a BIM-FM alternative, the research demonstrates how BIM functionalities and structured information exchange can enhance the efficiency and reliability of FM processes during the operation and maintenance phase.

The case study results indicate that the proposed framework enhances access to accurate asset data, reduces document retrieval time, and facilitates systematic planning for preventive maintenance. Integrating BIM models with COBie datasets provides a centralized and standardized data environment that strengthens collaboration between FM staff and external contractors. These advancements contribute to better decision-making, reduced operational disruptions, and enhanced sustainability of educational facilities.

Notwithstanding these advantages, the research identified several barriers to BIM implementation in developing countries, such as deficiencies in technical expertise, lack of BIM standards for O&M, and financial constraints. These factors emphasize the critical need for progressive deployment techniques, prioritizing high-impact technologies over early and comprehensive digital transformation.

To confirm its scalability across diverse organizational contexts and facility types, the proposed framework should be applied to a wider range of school buildings in further studies. Quantitative performance indicators, such as maintenance time, cost savings, and operational disruptions, can be monitored to evaluate long-term benefits. To enhance data-driven FM at a broader institutional level, future research may investigate integration with GIS platforms, remote inspection tools, and CMMS.

REFERENCES

1. AlMazrouei M., Ahmed R., Muckattu J. Management of Facilities Services Across ADNOC Group Companies. Society of Petroleum Engineers ADIPEC. 2023. <https://doi.org/10.2118/216486-ms>
2. Challender J., Challender R. Building and Facilities Maintenance Management. CRC Press, 2024. [2] <https://doi.org/10.1201/9781003358800>
3. Alotaibi F.F. Analyzing the Relationship Between Sustainability and Maintenance in the Facilities Sector // OMAINTEC Scientific Journal. 2023. Vol. 23, No. 68.
4. Teicholz, Paul, ed. BIM for facility managers. John Wiley & Sons, 2013.]
5. Duong H.D., Lin J.J. Reality model-based facility management framework for existing building. *Frontiers in Built Environment*. 2022; 8: 815672.
6. Bortolini, R., Forcada N., Macarulla. "BIM for the integration of Building Maintenance Management: A case study of a university campus." *eWork and eBusiness in Architecture, Engineering and Construction: ECPPM 2016*. CRC Press, 2017. 427-434.]
7. Congiu E., Quaquero E., Gola G., Pani F.P. Building information modeling and geographic information system: integrated framework in support of facility management (FM). *Buildings*. 2024; 14(3): 610.
8. Su Y.C., Lee Y.C., Lin Y.C. Enhancing maintenance management using building information modeling in facilities management. 28th International Symposium on Automation and Robotics in Construction, ISARC 2011. 2011.
9. Ariffin E.Y., Mustafa N.E., Sapri M. Perspective towards the Perceived Benefits and Challenges on Building Information Modelling-Facility Management (BIM-FM) Integration at an Early Stage of BIM Projects. *International Journal of Real Estate Studies*
10. Naji K.K., Gunduz M., Al-Qahtani A. Unveiling Digital Transformation: Analyzing Building Facility Management's Preparedness for Transformation Using Structural Equation Modeling. *Buildings*. 2024; 14(9): 2794.
11. Opoku A., Lee J.Y. The future of facilities management: managing facilities for sustainable development. *Sustainability*. 2022; 14(3): 1705.
12. Azhar S. Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadership and management in engineering*
13. Waqar, A., Othman, I., Hayat, S., Radu, D., Khan, M. B., Galatanu, T. F., ... & Benjeddou, O. (2023). Building information modeling—empowering construction projects with end-to-end life cycle management. *Buildings*, 13(8), 2041.]
14. E. Teicholz. Facility design and management handbook. McGraw-Hill Education. 2001. 752 P.
15. Spinner A., Degani A. Online as-Built Building Information Model Update for Robotic Monitoring in Construction Sites. *Journal of Intelligent & Robotic Systems*. 2024; 110(2): 50.
16. Chatsuwan M., Kim S., Jha N.K., Mahdjoubi L., Gidado K. BIM-FM interoperability through open standards: a critical literature review. *Architecture*. 2025; 5(3): 74.
17. Altwassi E.J., Aysu E., Ercoskun K., Abu Raed A. From design to management: exploring BIM's role across project lifecycles, dimensions, data, and uses, with emphasis on facility management. *Buildings*. 2024; 14(3): 611. doi.org
18. Pan X., Zhang Y., Yang Y., Li Y., Zhao L. BIM adoption in sustainability, energy modelling and implementing using ISO 19650: A review. *Ain Shams Engineering Journal*. 2024; 15(1): 102252.
19. Enoma A. The role of facilities management at the design stage. 21st Annual ARCOM Conference. London: SOAS, University of London, 2005; 1.
20. Gordo-Gregorio P., Alavi H., Forcada N. Decoding BIM challenges in facility management areas: a stakeholders' perspective. *Buildings*. 2025; 15(5): 811.

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