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Heritage Buildings Maintenance Trends In Egypt, From Integration To Inclusion

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Abstract:
Heritage building information modeling (HBIM) can be considered a tool that can be utilized as an approach for heritage buildings' maintenance plans, as maintaining these valuable buildings, either for unexpected events or preventive maintenance, can improve communication and integrate all of the necessary information together. HBIM can streamline the maintenance decision-making process by providing a digital representation of the heritage building's characteristics and its state of conservation, so the information can be more evident to a decision. Because maintenance is sometimes seen as a luxury and not a top priority in developed countries, this research proposes a solution for putting accurate and precise maintenance programs into practice and establishing a database that might improve Egypt's maintenance strategy for heritage buildings. Because they are not crucial to keeping the building operational, mandatory maintenance activities are treated as minor issues and dealt with in conventionally. There is currently no convenient mechanism in place to anticipate the effects of maintenance or to document the lessons learned from the previous repairs, meaning that the managerial and technical teams on every site have to start from the beginning without being able to use previous experience data from similar cases. The seventh pillar of BIM which related to facility management is a strategy for managing building upkeep and improving building efficiency by maintaining it. Additionally, BIM when it is used on heritage buildings, it is referred to by the term HBIM as the word heritage is being add. this can be defined as

an illustrative long-term answer to the problem of performing maintenance on heritage buildings. Old and deteriorating buildings that need measures to keep them safe and reusable in the face of gradual, slow deterioration, which can be termed as a silent killer.

Key Words:

HBIM; facility management; preventive conservation; NAVIS works; architectural visualization; virtual reality

Introduction

The use of technology to preserve heritage buildings might be thought of as a civi-lized conversation between the old and the new, given the precision with which such technologies can assess the condition of historic structures and prioritize repairs.

To illustrate buildings status for maintenance purposes, capturing data using 3D laser scans of real buildings is used to transfer all of the parametric solids to the REVIT family format, which is the required step in the engineering reversed sequence used by the BIM technology tool while dealing with existing buildings. As a result, information can be digitized and visualized to produce a multi-discipline engineering model that accurately depicts the built environment's physical components, assigning data to each component and compiling a history of the components and their associated maintenance processes, materials, cost and time requirements. Also information about the element's stage of development and its level of detail is assigned and recorded across time. The HBIM platform is a multi-user interface that allows teams to work at the same time and manage changes as they appear in all of the machines and links simul-taneously. Many outputs can be produced as needed for maintenance programs, such as quantities, procurement, time, cost, resources, as well as deterioration maps.

HBIM technique has proven usefulness for modelling, documenting, preserving, and classifying historical architectural characteristics. The production of a model of a heritage building is made possible through the collection of visual data through the use of 3D laser scanning and photogrammetry. As part of the process of laser scanning, a series of digital data points are gathered in order to represent the geometric coordinates of the surfaces of the heritage structures in three-dimensional space. The laser scanner focuses a beam of light on its target, and the reflected light is then utilized to identify the precise three-dimensional dimensions of the building being scanned [1].

The produced model and its related level of development and details can be as-signed to future intervention dates to organize an interactive maintenance program in relation to building status. Maintenance programs can be developed according to the continuous ongoing data feed and changes recorded in the model and updated by the site maintenance commission. Every era of Egyptian history shares many commonali-ties within its heritage buildings in its material, design, and craftsmanship; thus, it is possible to record, according to state, every aspect of the building to be utilized for fu-ture similar cases, thanks to the evolution of the modified data updates which inte-grating all disciplines [2].

2. Materials and Methods

A case study is treated as an experimental approach, with data, status, mainte-nance activity simulations, and the time and cost estimate all simulated in detail. Pal-ace of prince Taz is the case study which incorporating an experiment and a simula-tion to adopt the features of the state of conservation and its maintenance require-ments. This method can examine a wide range of potential factors, subsequently facil-itating maintenance-related decision-making. The information feed for the HBIM in the seventh dimension of BIM for facility management came from the selected case's maintenance processes.

REVIT was used to generate the 3D model and the facility management COBie plugin was used to generate the maintenance programs. Data were processed and an-alyzed by Microsoft power Bi software to display cost and time analysis and record the various packages of maintenance to be used as a database categorized by items, the data used in this study were focused on the architectural conservation activities of maintenance.

3. The Concept of Heritage Facility Management

facilities management is still widely misunderstood as it is relatively new field, it could be defined as the ability to integrate fundamentals into building. Facilities man-agement has to try to resolve disputes and identify synergies in the face of increasingly complex building systems, a larger diversity of user involvement, and an aversion for operational risk. It's probably not a coincidence that the Portuguese and Spanish words for "facilities" mean "ease" or "comfort" in those languages. The facility manager's job depends heavily on the concept of "ease of use." However, the managerial challenge of making solutions accessible and suitable is often disregarded in the context of sustain-ability, where there is a strong desire to adopt new technologies [3].

The purpose of facility maintenance is to ensure that a building continues to func-tion optimally for its intended use throughout its lifespan. The primary goal is to en-sure that the facility's functionality does not degrade to an unacceptable level. Repairs, on the other hand, are made for deteriorating facilities in order to get them back into serviceable shape. Treatment and reactive measures conducted after the whole or par-tial performance loss of facilities are not an option for historic structures. Therefore, the building must undergo iterations of multi-maintenance plans during its entire planned lifespan.

"Facility management" refers to the process of overseeing and ensuring the smooth operation of a building from the moment it is constructed until it is demolished. This includes everything from the building's infrastructure (electrical, sanitary, and me-chanical) to its surroundings, to its surveillance and security systems, to its cleanliness, to the maintenance of its individual components, to ensuring their peak efficiency.

also FM is the process of planning, implementing, and overseeing the provision of facilities (specifically, the services and buildings needed to support and facilitate the company's activity) to achieve and maintain performance levels that meet the needs of the establishment and provide employees with comfortable and productive work en-vironments. In other words, facility management is a practical term for the manage-ment of physical spaces within an organization [4].

According to the International Facility Management Association (IFMA), facility management involves the following managerial aspects related to various tiers of the presented information are used to aid in the decision-making process during the maintenance procedure. This takes into account a process that varies according to the heritage building's status, and hence the necessary action varies as follows:

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o When problems arise in a structure, maintenance is performed without a predetermined plan that takes into account the history of similar repairs to individual components.

o The goal of correction maintenance is to restore a building to its pre-defect state, so that it may continue functioning normally.

o Unanticipated building repairs due to major damage are examples of emergency maintenance. Most of the time, this is expensive and per-formed once.

o The term "planned maintenance" refers to the process of anticipating the need for repairs and arranging for them to be performed in specific peri-ods based on past experience and data gathered from the building's sys-tems.

o A heritage building's preventative maintenance plan starts with a series of inspections and tests to determine which parts of the building need to be maintained and how much work needs to be done.

o When a building's structural, architectural, sanitary, electrical, or elec-tro-mechanical components suddenly stop working as intended, it re-quires the skilled attention of a maintenance crew trained in corrective maintenance [5].

while managing a facility like heritage sites and urban amenities both are the up-keep of urban infrastructure and structures and the implementation of preventative maintenance programmes. These are just two of the many technical responsibilities. The implementation of heritage facility management in accordance with international, national, and regional heritage norms and laws was universally acknowledged as a de-fining aspect of heritage facility management.

whatever other means are required Finding a balance that allowed for efficiency, empathy, and authenticity was the obstacle that needed to be overcome due to value and authenticity of those precious buildings[6].

4. Using Heritage Buildings Information Modelling HBIM in Maintaining Heritage Buildings

As a result of the conservation condition, it is now essential for the existing digital paradigm to include mechanisms for the management of new data layers. The building information modelling (BIM) model needs to be adaptable enough to take into consid-eration all of the building's possible end uses at any given point in time and in any given setting in order to stay true to its original purpose of organising the whole life cycle of a structure. It is not difficult to consider traditional building information mod-elling (BIM) for new construction when one is shown a diverse variety of case studies. There is an immediate and critical necessity to include HBIM into the law. It is impos-sible for a set of tools that were first intended to manage, albeit exceptionally well, primarily new construction projects to accommodate the requirements of the con-structed, where the constructed refers to both new construction and structures that have already been built. Specifically, the latter is founded on a building model that is somewhat comparable to that of industrial processes and prefabrication. This is be-cause the later is built on a prefabricated model. It is required to undertake a review of the BIM process and logical scheme in order to acquire standards that can be applied to all buildings, even historic ones [7].

To keep track of the heritage maintenance activities being performed, monitoring is currently conducted on the basis of in-person site visits to ensure that the work is completed safely, in a timely and high-quality manner. These inspections are not reg-ularly conducted due to the expense and time involved, which may impede the imme-diate discovery of faults and result in large future expenditures to handle issues. The BIM model is a tool for analyzing and monitoring operations, which is used in this re-search as a novel computational platform for the maintenance requirements of facility management and data recording for future research and use. The COBie plugin and the BIM's seventh dimension were exported from Autodesk Revit to illustrate the maintenance programs analyzed by the Microsoft power BI plugin to allow both pieces of software to achieve inclusion after integration, as achieved by BIM.

BIM simulates the structural and functional elements of historic buildings digital-ly, as it provides the modeled content needed for maintenance program inputs. In sev-eral maintenance stages, BIM is heavily used, which aids the site commission in re-ducing omissions and errors, working with stakeholders to limit rework, and saving time and money for the project. In the building's operation, BIM helps to locate and manage the building components and facilitates the management of the heritage building. BIM improves access to accumulated lifespan information. Because of the advantages this model offers to owners and facility managers, they frequently ask for accurate project models. The possible advantages of BIM are more well-documented and often depend on delivering precise information from construction team members to the owner at the end of the project. However, the delivered precise information can be reused in practice for the same building or for similar materials or repairs cases.

BIM has increasingly been used during maintenance for applications including the creation of an accurate geometric representation of the parts of a building in an infor-mation-rich environment, managing scheduling concerns, managing cost control pro-cesses, and monitoring environmental data. Several applications focus on obtaining value from BIM in conservation [8].

The dimension that facilitates the management of current buildings and stream-lines all actions, both routine and extraordinary, that must be carried out during the facility's lifetime is the seventh dimension of building information modelling, also known as 7D BIM, being one of the most prominent aspects of BIM. Its purpose is to enhance the management of the maintenance of facilities by collecting, preserving, generating, updating, and sharing documents related to the building's history (includ-ing data sheets, user manuals, warranty documents, reports, and plans).

To maintain the performance standard of the heritage buildings components, 7D BIM is a novel approach in which everything related to the facility management pro-cess is compiled into a single building information model. This is undertaken to keep track of the building's information, especially since the aim is to maintain the life cycle forever for the benefit of future generations.

7D BIM enables the management of the building and associates the information with the model that is necessary for managing the asset and its maintenance. In this manner, information can be exchanged between the many stakeholders, the imple-mentation can take place on schedule at all times, and there is no risk of the data being lost.

Integration of BIM into facility management makes it possible to develop more ef-ficient operations by cutting down on time-consuming actions. The seventh dimension of BIM has been responsible for the management and maintenance of construction throughout the operating phase for several years. Since BIM is still capable of incorpo-rating newly discovered methods, its significance will certainly grow with time [9].

5. Integration of HBIM and Facility Management

HBIM has many levels of integration; for example, if assigned to cyber-physical sensors, it can establish the heritage building's status using sensors that collect infor-mation such as temperature and humidity. Then, then it sends these data to the main simulated model. An alarm will be activated if the data exceed the normal level, trig-gering emergency maintenance. Moreover, warning notifications can be sent to the occupants' mobile phones and the facility management team [10]. Additionally, it can share, analyze, and develop specific data from a building's in-tegrated complete database. Therefore, it can recommend an adequate basis for deci-sions, which could help to reduce costs, time, and rework and avoid conflicts [11].

Integrating the building information modelling (BIM) technique with facility management makes it possible to achieve the best potential results in managing an as-set.

The BIM model serves as a digital representation of the real-world asset; it is a faithful simulation of the real thing, including information on every part of the present structure. Therefore, it becomes an important tool for simulation and programming that may be utilized to arrange for the asset's maintenance.

This method makes routine tasks easier to complete (such as researching infor-mation, conducting surveys, and writing files), assures a more in-depth knowledge of the heritage building's consistency, identifies potential issues, and makes the building's behavior and performance more efficient.

The need to use BIM with FM was emphasized throughout this research to pro-vide more effective maintenance through developing technology for data capture, such as smart sensors or reports of required maintenance issued by the professional to be inserted and assigned to the modeled buildings' components. The case study on the applicability of the suggested paradigm to the palace of Prince Taz, presented as a comprehensive system for accessing and exchanging information between the many stakeholders involved in building maintenance, is presented here.

It was decided to design a prototype for the strategic maintenance of Egypt's her-itage buildings, through a heritage building information modeling (HBIM) system that would allow for the dynamic exchange and updating of architectural data, integrating other pieces of software into the model to design solutions capable of handling external data sources [12].

In this research, HBIM was used for an intervention study of a heritage building in relation to maintenance process, and it required a rigorously correct and thorough characterization of the design of the building. To accomplish this goal, the heritage building was simulated and assigned maintenance requirements, time and cost. As a result, a set of families of architectural components were defined, which made it possi-ble to create a realistic model of the chosen case study, the Islamic Egyptian monument of Prince Taz palace. The parametric modeling of key architectural aspects made pos-sible by these technologies led to the creation of the new families of facades, wooden floors, staircases, and the roof, as well as their ornamental stonework elements. The object tool made it possible to incorporate the physical characteristics of the materials that were actually used in the construction of the heritage building.

Every heritage building will be a layer in future archiving. All categorized Egyp-tian heritage buildings can be a link within the heritage facility management library and can use the lessons learned from stone or wooden conservation as categorized un-der a certain deterioration case [13].

Some heritage maintenance projects are unable to reap the strategic benefits that could be realized by employing a BIM approach since some of the stakeholders in-volved in the historic sector have minimal experience with BIM. So, this reduce their ability to communicate with the HBIM models outputs were deemed to be quite ad-vantageous due to their visual interfaces and simplicity, but stakeholders may need training to fully appreciate the potential of the technology before they can begin to de-sign their operations within an HBIM environment. especially when one takes into ac-count the fact that this is a common gripe voiced by participants from a variety of na-tions, including Egypt [14].

6. From Integration to Inclusion via COBie

integration is component of innovation that foreshadows the creation of effective and practical integrated methods for the preservation and improvement of historic buildings. It's also helpful for setting priorities and making long-term plans for how much money will be spent on preserving and maintaining cultural artefacts [15].

This integration can be achieved when Data for manageable assets can be export-ed from building information modeling (BIM) design software and loaded directly into facility management (FM) and operations and maintenance (O&M) software using the COBie data interchange protocol. COBie, Construction Operations Building Infor-mation Exchange, is a proprietary program that was created by the Construction In-dustry Institute (CII) [16].

Having such programs can make it clearer as to which data should be collected, how these data should be integrated with the heritage building to achieve inclusion, and also at which moment the supply of information should be initiated. In spite of this, despite the fact that the BIM can be integrated with building facility management, it illustrates the heritage references to data models and information exchange stand-ards precisely, in addition to enhancing the usability and comprehension of infor-mation exchange, which is required for stakeholders to make decisions. Therefore, the platform of HBIM, the COBie plugin and the Microsoft power Bi standards were con-nected as a FM nexus.

The primary output of the COBie plugin is a spreadsheet that can be opened, ed-ited, and manipulated, including standard procedures and features such as sorting, querying, and elementary arithmetic operations. Deliverables in the COBie format take the form of spreadsheets with various workbooks and columns, which users may either populate by hand or automatically via the database mappings or export tools of build-ing information modelling (BIM) and computer-aided facility management (CAFM) applications. The time, money, and effort needed for maintenance are all factors that can be found here. A COBie spreadsheet can comprise hundreds of rows of facility data depending on the project's delivery stage and scope [17].

Despite spreadsheets' usefulness, simplicity, and ease of use, serious mistakes are not uncommon. The surface level of a spreadsheet seems like a table, however the connection between the establishes deep-level connections between cells and their de-pendencies

Because of this, it's challenging for a user dealing with the tabular layer to make sense of the data because it's spread out across multiple cells and workbooks.

To infer the semantic connection between cells, columns, and workbooks, users frequently resort to time-consuming and taxing visual examinations. Users' ability to identify and comprehend important data is hindered by the complexity of spread-sheets [18].

During the maintenance process, COBie helps to capture and record project data such as equipment specifications, product data sheets, and maintenance schedules in an organized form. This inclusion helps to reduce the cost of maintenance and save costs. The technique known as VisualCOBie offers an innovative user interface and a platform for managing information. Potentially, this work could lead to a significant shift in how we represent and employ information exchange standards such as COBie, which are essential to advancing BIM for heritage building maintenance research and applications, and this can bridge the gap between integration to inclusion.

To apply HBIM in maintenance and facility management following the standard set by the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM), the capability to compare findings is essential. The crea-tion of diagnostic and analytical methods is required to maintain and save heritage buildings. Because of this, ICCROM establishing standard operating procedures for this line of

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work is necessary. As a result of the significant amount of time and effort required to formulate an individual maintenance plan for each feature, there is a sig-nificant risk of making incorrect generalizations. As a result of this, the author sug-gests facilitating inclusion by orienting the facility management software and BIM to serve the state of conservation of heritage buildings, as well as constructing a frame-work for the database that can assess other similar buildings, specifically when they have the same status and design. This makes it possible to generalize the findings in some circumstances involving recurrent degradation by linking the specific facts [19].

When it comes to recording heritage buildings, numerous different groups of peo-ple with a wide variety of goals collect and use the various forms of information.

Because of this, information may get compartmentalized, and various stakehold-ers may behave in an autonomous manner. It is possible this research will be able to develop a setting in which information can be freely transferred between other do-mains if the requirements for record keeping get standardized. The findings will enable the recording of unique causes and therapies that can be used to situations that are analogous, as many studies use standardized methods of categorizing data. This is be-cause many studies use standardized methods of categorizing data. [20].

7. Analysis, Results and Discussion

The recommended method for the facility management and maintenance of her-itage structures was applied, and the Prince Taz palace was selected as the heritage building to be managed and maintained. The Prince Taz palace was established in 753 AH/1352 AD, during the Bahri

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Mamluk era of Islamic history. The As-Seyoufeia street side of the palace is visible from the main front of the building. When viewed from the east, the palace encompasses Ali Agha Dar As-sabiil Sa'ada's as well as Kottab, both of which were included in the palace after it was expanded in the year 1088 AH. The waqf house of Habiba Khatoon was established in 1264 AH and is located on the west-ernmost edge of the property. In addition to this home, there is a mosque and khanak-ah belonging to Aidkeen Al-Bendkari, both of which are known as "Zaweiat Al-Abar." The palace, on the other hand, has a view of Darb (the route of) Ash-Sheikh Khalil, which was formerly known as "Al-Mubayadiya alley" and which leads to the second-ary entrance that is currently closed due to a previous historic conservation project. This view can be accessed from the palace's south facade. The founder of this palace was Prince Saif Ed-Din Abdullah Taz Ibn Qatghag An-Naseri. The previous conserva-tion works started with heavy structural consolidation after the impact resulting from the 1992 earthquake which affected Egypt and destroyed several heritage buildings; this palace was one of the heavily deteriorated buildings in Islamic Cairo, and the architectural conservation was performed according to its authentic origins. The deci-sion was made to document all of the conservation activities, meaning that the history of the previous related restoration was recorded for every element and was tradition-ally archived on paper and in CAD files, reports, and photographic documentation [21]. Please see the palace's architectural composition in Figures 1 and 2, in addition to the traditional architectural plans documented by CAD in Figures 3 and 4.

Figure 1. The palace of prince Taz in Cairo.

Figure 2. The main façade of Taz palace.

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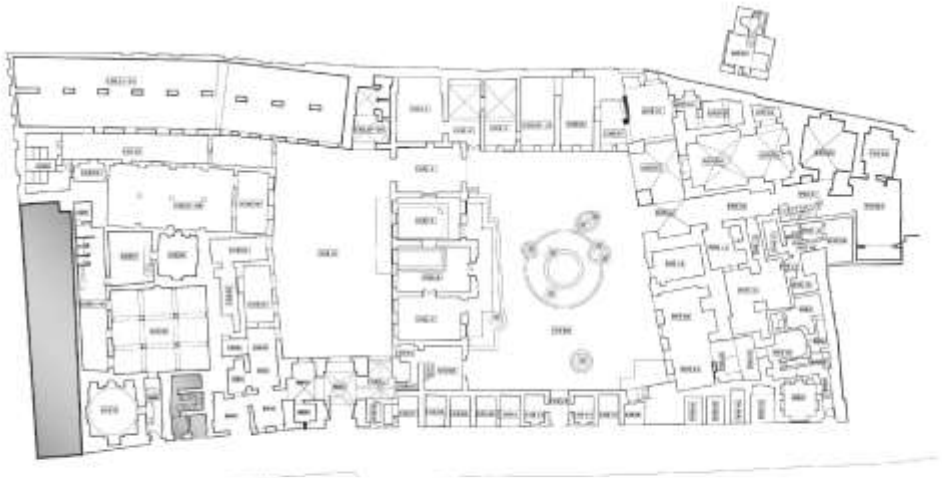

Figure 3. The palace ground floor plan.

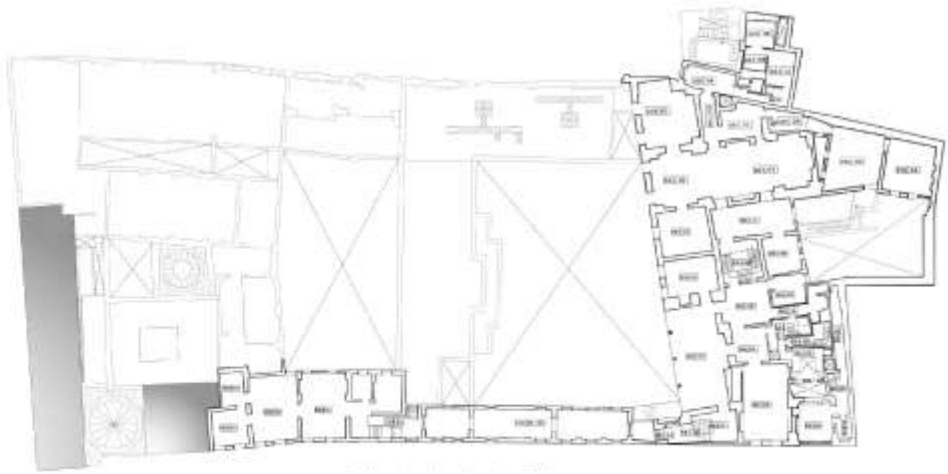

Figure 4. The palace first floor plan.

In recent years, there have been significant advancements made in the digitization of built heritage as well as the related registration processes of the surrounding environment. These advancements have made it possible for these processes to rapidly reach many users across a variety of devices. The creation of data gathering systems that are flexible and adaptive is therefore vital if one wants to achieve the goal of providing an effective interface between software and physical data. In the process known as "Scan-to-BIM," data from a scan is utilized within BIM software to generate an intelligent 3D representation of a place. [22].

Depending on the previous mentioned digitization concept the model was developed from CAD data with the assistance of 3D laser scans, and it was then analyzed by the REVIT software to be prepared for BIM, as shown in Figures 5–9. The spaces were categorized by their names, and then the materials were assigned, in addition to the maintenance information that was integrated with every feature of the heritage building at each stage of maintenance.

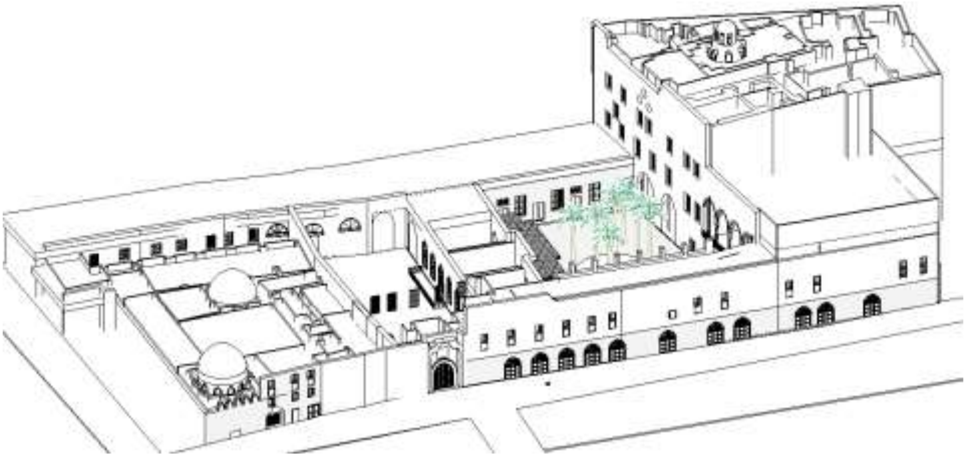

Figure 5. The Taz initial model.

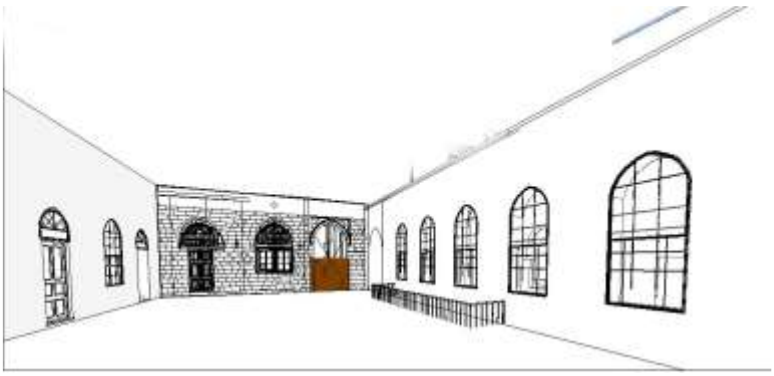

Figure 6. The computer-aided representation of the physical features of the first court.

Figure 7. The computer-aided representation of the physical features at the main court.

Figure 8. the original building first court.

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Figure 9. the main court original image which built at the model.

The COBIe plugin demanded the manual opening of many fields as database mappings in addition to the automatically generated data of area calculations and percentages of the total floor area. This was necessary in order to export the information automatically for the other necessary functions and maintenance procedures, as shown in Tables 1 and 2 in addition to Figure 10.

Table 1. Ground floor area statistics from COBie.

COBie	FLOORNAME	NAME	CREATEDON	Area	Assignable Area	Assignable Area %	Net to Gross%
	Gr Floor Plans	A00-01	2022-11-28T15:47:40	52 m²	52 m²	2.07%	2.07%
	Gr Floor Plans	A00-02	2022-11-28T15:47:40	10 m²	10 m²	0.42%	0.42%
	Gr Floor Plans	A00-03	2022-11-28T15:47:40	16 m²	16 m²	0.64%	0.64%
	Gr Floor Plans	A00-04	2022-11-28T15:47:40	7 m²	7 m²	0.27%	0.27%
	Gr Floor Plans	A00-05	2022-11-28T15:4	41 m²	41 m²	1.63%	1.63%

			7: 40				
	Gr Floor Plans	A00-06	2022-11-28T15:47:40	54 m²	54 m²	2.15%	2.15%
	Gr Floor Plans	A00-07	2022-11-28T15:47:40	159 m²	159 m²	6.35%	6.35%
	Gr Floor Plans	B00-01	2022-11-28T15:47:40	27 m²	27 m²	1.07%	1.07%
	Gr Floor Plans	B00-02	2022-11-28T15:47:40	20 m²	20 m²	0.80%	0.80%
	Gr Floor Plans	B00-03	2022-11-28T15:47:40	20 m²	20 m²	0.78%	0.78%
	Gr Floor Plans	B00-05	2022-11-28T15:47:40	24 m²	24 m²	0.98%	0.98%
	Gr Floor Plans	B00-06	2022-11-28T15:47:40	20 m²	20 m²	0.81%	0.81%
	Gr Floor Plans	B00-07	2022-11-28T15:47:40	11 m²	11 m²	0.43%	0.43%
	Gr Floor Plans	C00-01	2022-11-28T15:47:40	20 m²	20 m²	0.80%	0.80%
	Gr Floor Plans	C00-02	2022-11-28T15:47:40	7 m²	7 m²	0.28%	0.28%
	Gr Floor Plans	C00-03	2022-11-28T15:47:40	6 m²	6 m²	0.22%	0.22%
	Gr Floor Plans	C00-04	2022-11-28T15:47:40	5 m²	5 m²	0.19%	0.19%

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Table 2. first floor area statistics from COBie.

COBie	FLOORNAME	NAME	CREATEDON	Area	Assignable Area	Assignable Area %	Net to Gross%
Yes	1st Floor Plans	D01-03	2022-11-28T15:51:19	60 m²	60 m²	2.40%	2.40%
Yes	1st Floor Plans	D01-04	2022-11-28T15:51:19	20 m²	20 m²	0.79%	0.79%
Yes	1st Floor Plans	D01-05	2022-11-28T15:51:19	18 m²	18 m²	0.72%	0.72%
Yes	1st Floor Plans	D01-06	2022-11-28T15:51:19	38 m²	38 m²	1.51%	1.51%
Yes	1st Floor Plans	D01-07	2022-11-28T15:51:19	19 m²	19 m²	0.77%	0.77%
Yes	1st Floor Plans	D01-08	2022-11-28T15:51:19	25 m²	25 m²	1.01%	1.01%
Yes	1st Floor Plans	D01-09	2022-11-28T15:51:19	29 m²	29 m²	1.16%	1.16%
Yes	1st Floor Plans	D01-10	2022-11-28T15:51:19	14 m²	14 m²	0.58%	0.58%
Yes	1st Floor Plans	D01-14	2022-11-28T15:51:19	21 m²	21 m²	0.83%	0.83%
Yes	1st Floor Plans	D01-15	2022-11-28T15:51:19	39 m²	39 m²	1.57%	1.57%
Yes	1st Floor Plans	D01-16	2022-11-28T15:51:19	38 m²	38 m²	1.50%	1.50%
Yes	1st Floor Plans	D01-17	2022-11-28T15:51:19	43 m²	43 m²	1.70%	1.70%
Yes	1st Floor	D01-18	2022-11-	16 m²	16 m²	0.66%	0.66%

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	Plans		28T15:5 1: 19				
Yes	1st Floor Plans	E01-01	2022-11-28T15:5 1: 19	15 m²	15 m²	0.58%	0.58%
Yes	1st Floor Plans	E01-02	2022-11-28T15:5 1: 19	11 m²	11 m²	0.43%	0.43%
Yes	1st Floor Plans	E01-03	2022-11-28T15:5 1: 19	21 m²	21 m²	0.82%	0.82%
Yes	1st Floor Plans	E01-04	2022-11-28T15:5 1: 19	4 m²	4 m²	0.16%	0.16%

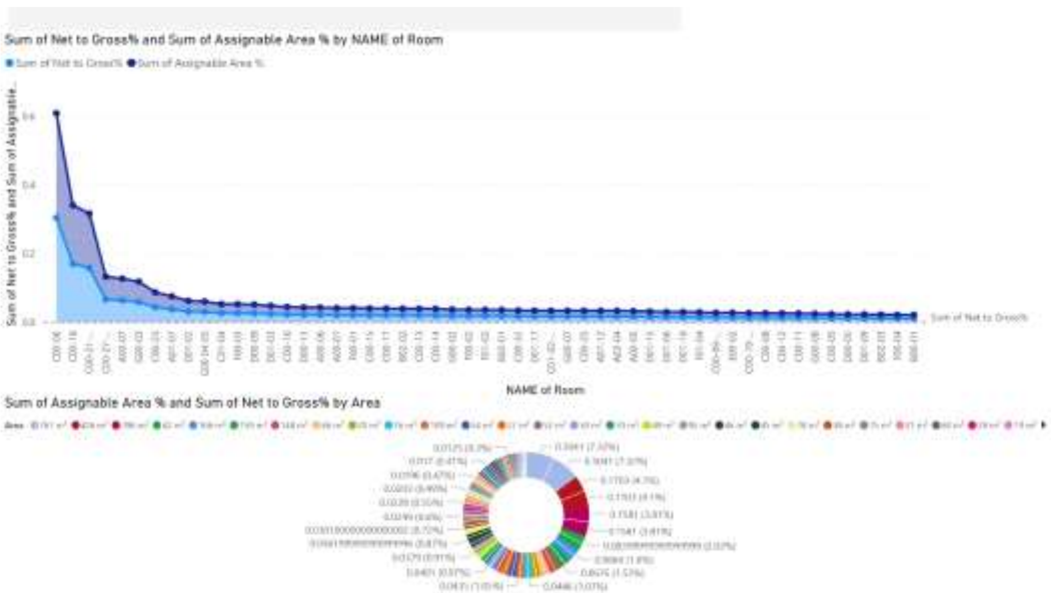

Figure 10. Microsoft power Bi plugin analysis of the output from COBie to ease its readability, represented by a line chart from the Visualizations menu.

As illustrated in Figures 11 and 12, zones were extracted and segregated from the list of BIM interoperability tools in order to describe maintenance data. The two primary courtyard spaces are highlighted in green and red, respectively.

the longer maintenance is ignored the more expected to be lost, The benefits that can be gained from this are important to review. Owners

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benefit from upkeep in two ways: it keeps the building looking good and keeps the value up, protecting the owner's investment. Cleaning up the gutters or replacing a loose tile might save a lot of money in the long run.[23] .

So four maintenance programs were assigned to every space in the palace, demonstrating the preventive maintenance requirements that are necessary to maintain the state of the features that are being conserved, followed by annual, short, medium, and long-term programs, the data that were inserted regarding the method of maintenance that must be performed in order to achieve a high-quality outcome, in addition to the cost and amount of time that is necessary, are presented in Table 3.

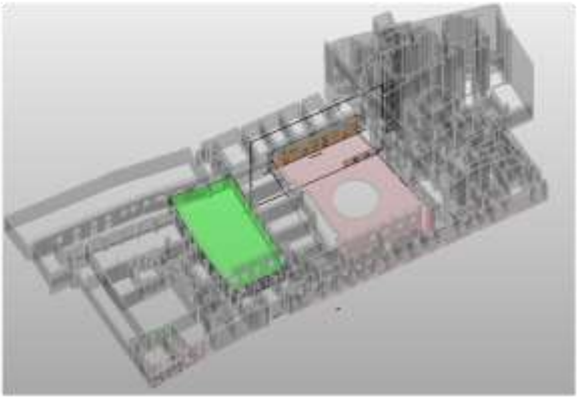


Figure 11. BIM and COBie Plugin interface, which show the highlights of the space.

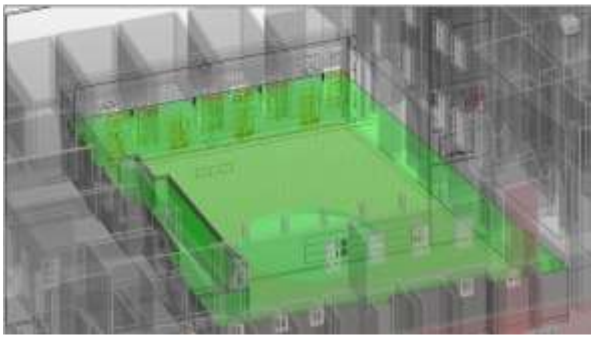
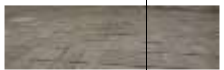


Figure 12. BIM and COBie Plugin interface, focus on the court.

Table 3. Maintenance programs' inclusion record for Taz's spaces.

COBie.Maintenance work for Room C00-06andC00-18												
Elevation	Floor FINISH	Ceiling Finish	Preventive Maintenance		Annual Maintenance		Short Term maintenance		Medium Term maintenance		Long Term maintenance	
				Cost	Time	Cost	Time	Cost..	Time	Cost	Time	Cost
		There is no ceiling in this room	10 days	15,000 2 Workers and Materil Of Refill	45 days	160,000 -stone replace -deep cleaning -joint refill	_	_	95 days	600,000 - stone replace -deep cleaning - joint refill	120 days	1,000,000 -stone replace injection -chemical and mechanical joint refill
		_	30 days	90,000	60 days	150,000 -marble -wooden -stone chemical cleaing -protection	_	_	_	_	90 days	5,000,000 -marbl -wood -deep chemical and mechanical cleaning

		_	20 days	50,000	50 days	110,000 -planter treatment -wooden treatment	_	_	_	_	60 days	200,000 deep chemical cleaing - plaster injection
		_	30 days	75,000	80 days	150,000 -planter treatment -wooden treatment	_	_	_	_	60 days	300,000 deep chemical cleaing - plaster injection
		_	20 days	40,000	50 days	100,000 -planter treatment -wooden treatment	_	_	_	_	60 days	200,000 deep chemical cleaing - plaster injection
		_	20 days	35,000	50 days	120,000 -planter treatment -wooden treatment	_	_	_	_	60 days	200,000 deep chemical cleaing - plaster injection
		_	20 days	30,000	50 days	60,000 -planter treatment -wooden treatment	_	_	_	_	60 days	250,000 deep chemical cleaing - plaster injection

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Table 4. Maintenance programs' inclusion record for Taz's detailed features.

COBie.Component Door maintenance											
Image	NAM E	Preventive maintenance		Annual maintenance		Short term maintenance		Medium term maintenance		Long term maintenance	
		Tim e	Cost	Tim e	Cost	Time. .	Cost	Tim e	Cost	Time	Cost
	D00-C00-6	7 days	7000 - injection treatment mechanical chemical -protection	10 days	10500	_	_	15 days	20000 -mechanical -chemical - injection -repaint - protection	25 days	30000 -mechanical -chemical -injection - repaint -protection
	D03-C006	5 days	6500 - mechanical -protection	10 days	9750	_	_	_	_	15 days	16000 -mechanical -chemical -injection - repaint -protection
	D04-C006	4 days	6000 - mechanical -protection	10 days	9000	_	_	_	_	15 days	15000 - mechanical -chemical -injection - repaint -protection
	D05-C00-6	4 days	6000 - mechanical -protection	10 days	9000	_	_	_	_	15 days	15000 - mechanical -chemical -injection - repaint -protection

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In Table 4, the detailed example features are presented, namely the doors, showing the price and the exact time of completion of all maintenance work concerning the estimated cost.

The output from COBie tables was reprocessed by Microsoft Power Bi. The time rate of the preventive maintenance stage for court spaces and the cost are visualized in Figures 13 and 14.

A line chart was visualized to demonstrate the average annual maintenance cycle time for the court spaces. Additionally, this representation can be used to compare the results to perform or avoid any unnecessary maintenance activities, as shown in Figures 15, 16 and 17.

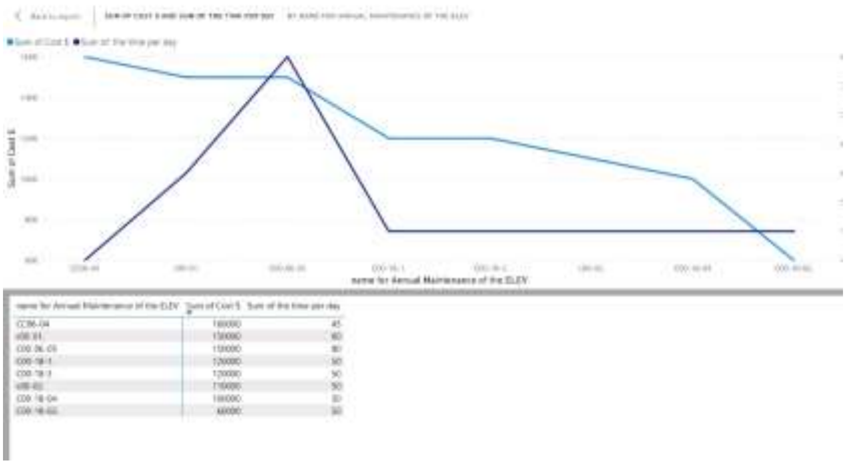

Figure 13. Sample court spaces' annual maintenance line diagrams of cost and time.

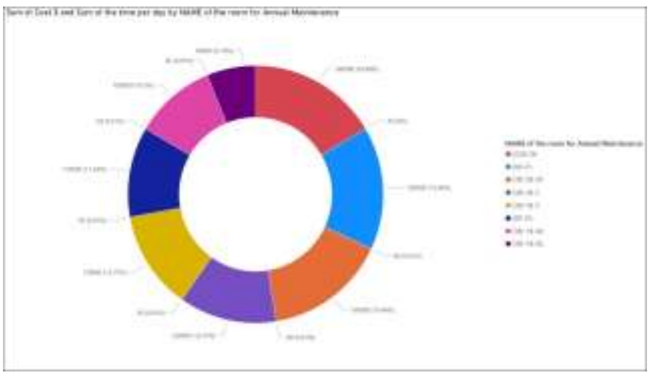

Figure 14. Sample court spaces' annual maintenance shows cost comparison.

Figure 15. Comparative analysis of different stages of maintenance to assess decision making.

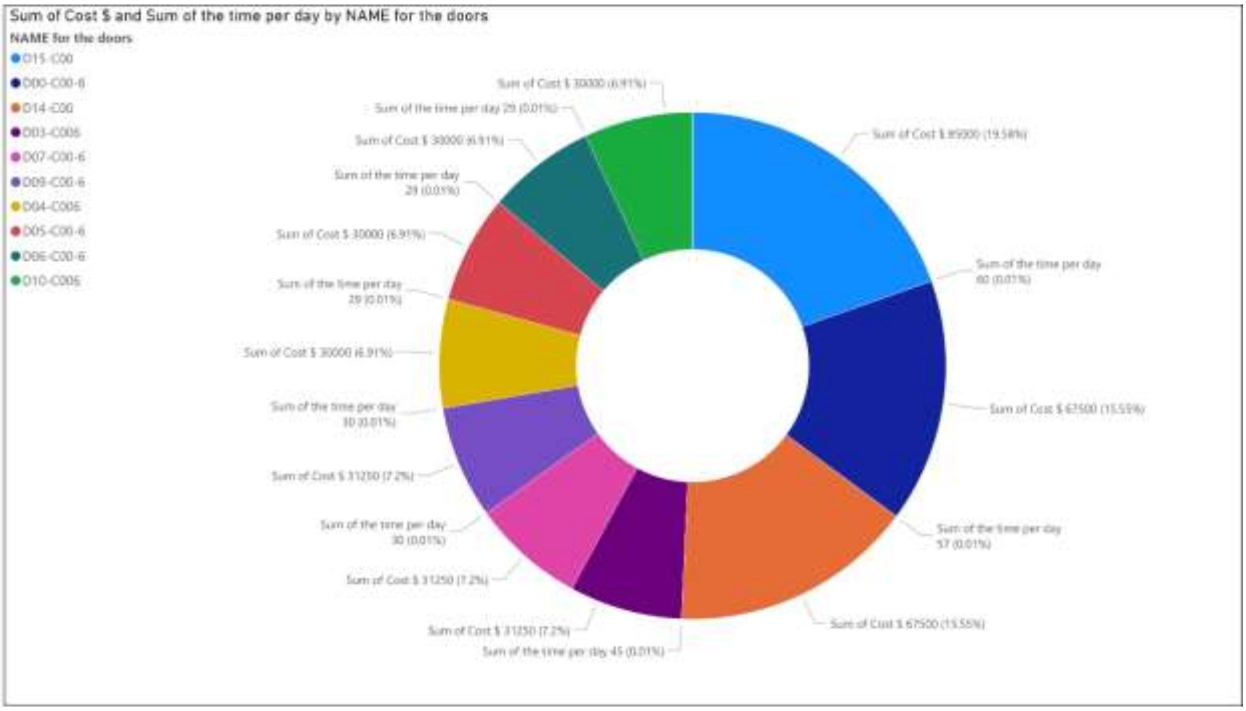

Figure 16. Accumulative cost analysis for features, doors shown as an example.

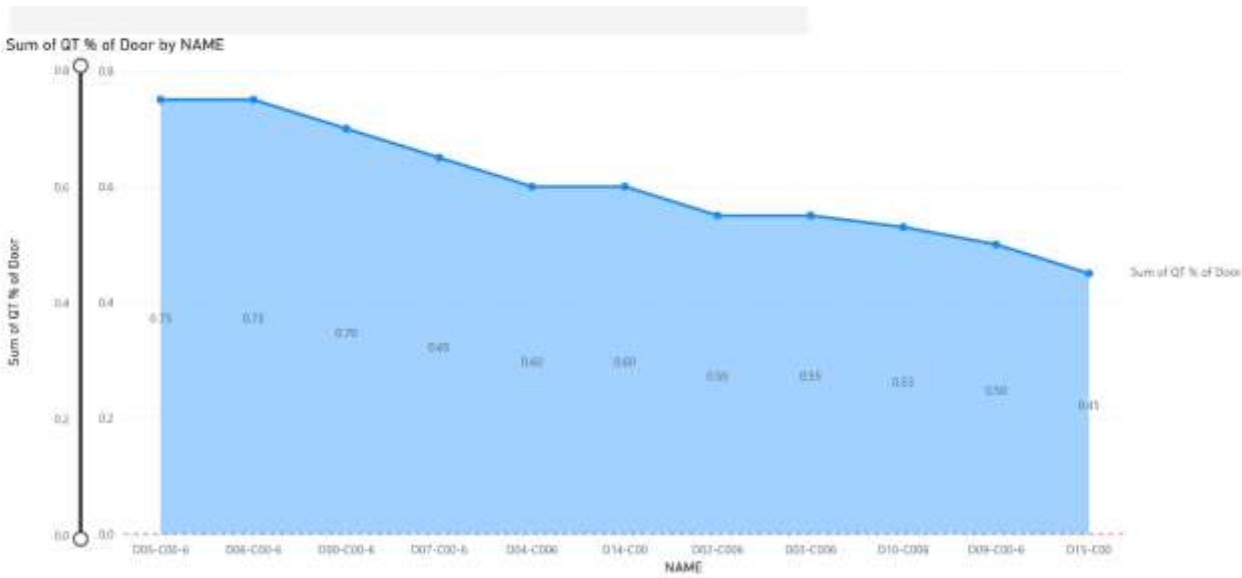

Figure 17. Doors' status of conservation—quality percentages to be used in decision making.

The integration of BIM and COBie results in the extraction of a set of spreadsheets containing data records for Prince Taz palace. These spreadsheets contain many fields of data inserted manually and automatically into the cells, as shown in Tables 5 and 6. Despite the fact that these data are specifically linked to a reference for maintenance, the process of inclusion connected to Microsoft Power Bi to produce data can evaluate maintenance decision making, particularly in terms of time and cost.

Table 5. The database entry interface through which data were manually inserted into COBie.

Title	COBie	
Version	2	
Release	4	
Status	IFC2x3	
Region	en-US	
Purpose		This COBie spreadsheet is an example file that comes with the COBie Extension 1.0
Outline		Individual worksheets are organized by project phase as shown below
All Phases	Sheet	Contents
	Contact	People and Companies
Early Design Worksheets	Sheet	Contents
	Facility	Project, Site, and Facility
	Floor	Vertical levels and exterior areas
	Space	Spaces
	Zone	Sets of spaces sharing a specific attribute
	Type	Types of equipment, products, and materials
Detailed Design Worksheets	Sheet	Contents
	Component	Individually named or schedule items
	System	Sets of components providing a service
	Assembly	Constituents for Types, Components and others
	Connection	Logical connections between components
	Impact	Economic, Environmental and Social Impacts at various stages in the life cycle
Construction Worksheets	Sheet	Contents
		NOTE: Submittals and approvals added on 'Documents' worksheet
		NOTE: Manufacturer and model added on 'Type' worksheet
		NOTE: Serial and tag added on 'Component' worksheet
Operations and Maintenance Worksheets	Sheet	Contents
	Spare	Onsite and replacement parts

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	Resource	Required materials, tools, and training
	Job	PM, Safety, and other job plans
		NOTE: Warranty information added on 'Type' worksheet
All Phases	Sheet	Contents
	Document	All applicable document references
	Attribute	Properties of referenced item
	Coordinate	Spatial locations in box, line, or point format
	Issue	Other issues remaining at handover.
Legend		
	Text	Required
	Text	Reference to other sheet or pick list
	Text	External reference
	Text	If specified as required
	Text	Secondary information when preparing product data
	Text	Regional, owner, or product-specific data
	Text	Not used
Notes		
		NOTE: Regional, owner, or product specific data may be added as new columns to the right of standard template columns.
		NOTE: Regional classification codes may be substituted for the specifiable picklists used in the United States.
Copyright	USACE ERDC	(c) 2006-2013

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Table 6. COBie spreadsheet extraction database information.

Name	CreatedBy	CreatedOn	Category	SheetName	RowName	Value	Unit	ExtSystem	ExtObject	ExtIdentifier	Description	AllowedValues
Author	<None>	2022-11-28T15:47:40	Approved	Facility	n/a	n/a	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1019005	n/a	n/a
Building Name	<None>	2022-11-28T15:47:40	Approved	Facility	n/a	n/a	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1019006	n/a	n/a
Category	<None>	2022-11-28T15:47:40	Approved	Facility	n/a	Project Information	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1140363	n/a	n/a
Client Name	<None>	2022-11-28T15:47:40	Approved	Facility	n/a	Owner	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1006319	n/a	n/a
Design Option	<None>	2022-11-28T15:47:40	Approved	Facility	n/a	n/a	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1013201	n/a	n/a
Family Name	<None>	2022-11-28T15:47:40	Approved	Facility	n/a	n/a	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1002002	n/a	n/a
Organization Description	<None>	2022-11-28T15:47:40	Approved	Facility	n/a	n/a	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1019007	n/a	n/a
Organization Name	<None>	2022-11-28T15:47:40	Approved	Facility	n/a	n/a	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1019008	n/a	n/a
Project Address	<None>	2022-11-28T15:47:40	Approved	Facility	n/a	Enter address here	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1006318	n/a	n/a
Project Issue Date	<None>	2022-11-28T15:47:40	Approved	Facility	n/a	Issue Date	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1006321	n/a	n/a
Project Name	<None>	2022-11-28T15:47:40	Approved	Facility	n/a	Project Name	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1006317	n/a	n/a
Project Number	<None>	2022-11-28T15:47:40	Approved	Facility	n/a	0001	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1006316	n/a	n/a
Project Status	<None>	2022-11-28T15:47:40	Approved	Facility	n/a	Project Status	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1006320	n/a	n/a
Type Name	<None>	2022-11-28T15:47:40	Approved	Facility	n/a	n/a	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1002001	n/a	n/a
Building Story	<None>	2022-11-28T15:47:40	Approved	Floor	Gr Floor Plans	1	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1007111	n/a	n/a
Category	<None>	2022-11-28T15:47:40	Approved	Floor	Gr Floor Plans	Levels	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1140363	n/a	n/a
Computation Height	<None>	2022-11-28T15:47:40	Approved	Floor	Gr Floor Plans	n/a	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1006939	n/a	n/a
Design Option	<None>	2022-11-28T15:47:40	Approved	Floor	Gr Floor Plans	n/a	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1013201	n/a	n/a
Elevation	<None>	2022-11-28T15:47:40	Approved	Floor	Gr Floor Plans	n/a	n/a	Autodesk Revit 2021, Build: 21.0.0.383	Autodesk.Revit.DB.Parameter	-1007102	n/a	n/a

8. Conclusions

From limtations of the inclusion parties which had been raised at this research, that COBie was developed within the context of building information modelling (BIM) with the express goal of transporting data generated during the design and construction phases of a project into the operations and maintenance stages of that project. On the other hand, digital data-based maintenance information management is an area of infrastructure that has not been subjected to extensive investigation. This is because it is a relatively new area of study. Because a facility, once it has been established, often requires maintenance for a longer period of time than other facilities do, facility maintenance is extremely important.[24] The ease of access to information is the most pressing problem that facility managers must address. Although building information modelling (BIM) has been suggested as a method to enhance the quality and accessibility of asset information in support of facilities management (FM), very few studies have captured the challenging aspects of developing and delivering this information within the context of actual projects with owner-defined information requirements. While BIM has been suggested as a method to improve the quality and accessibility of asset information, FM has been shown to be ineffective in improving the quality and accessibility of asset information .[25]

The current body of research does not adequately describe the interaction that must take place between conservation architects, their clients, and the end users, in order to achieve maximum effectiveness. This can be used to develop a model for inclusion and operations to enhance building efficiency by examining the impact of essential success elements already raised at a case study set [26]. This can be done by using a set of case studies and compare results as inclusion mean using integrated maintenance data for other cases of maintenance depend on the recorded lesson learned for the same heritage building or for other building refer to the same era .

The management and upkeep of buildings are essential components of the life cycle of facilities; nevertheless, these aspects of the building should be taken into consideration from the very beginning of the design process. The frequency with which the facility is used is one of the factors that must be considered, along with the number of facilities, the total number of facilities, the maintenance period, the maintenance techniques, the expenses, the vulnerabilities of the facilities, and the features of the facilities. That is to say, it is absolutely necessary that the architect of the building take into consideration how the organisation of the building's materials will influence the building's amenities while designing the structure (such as their longevity and ease of replacement). If these features of a structure are properly analysed from the very

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beginning and recoded, it is possible to limit the costs of maintaining and managing the building to a minimum.[27]

to conclude a growing appreciation for the seventh dimension of building information modelling (BIM) integration with facilities management has been shown in recent studies. A platform can assist in the proposal of inclusion which introduced here at this research, because there is a tremendous demand for a centralized hub capable of processing all of the data required to care for heritage buildings across time. The purpose of this model is to propose early-stage improvement ideas based on anticipated outcomes from the combination of BIM and FM integration at the seventh dimension which recorded for multi cases of maintenaning heritage buildings. Despite the fact that such an integrative method has the potential to produce a number of beneficial results, such as relating performance levels to maintenance planning, amongst others, the benchmarking was tested at this research in a few instances by using massive amounts of data and facts regarding the limitless maintenance schedules required for ancient buildings.

Existing COBie spreadsheets have the potential to enhance both their functionality and their usability if they are combined with HBIM as a framework and platform. This is accomplished by offering a BIM-integrated and graph-based visualization and data navigation platform. This is made possible by the COBie features that allow for graph-based visualization as well as data navigation. This is accomplished through utilizing BIM and graph-database software on the data integration and processing layer, which is responsible for combining these points of view. In order to accomplish this goal, we obtained the necessary BIM data by using the standard database for the BIM which presented and visualized by Microsoft Bi to ease redability for non-professionals.

The approach has been externally validated by data from a case study performed in Egypt. The Egyptian government recently conserved a historic building with a lengthy history of decay, and it is now responsible for ensuring its continued good condition. The purpose of this work is to establish a benchmark for establishing a maintenance strategy for all such buildings referring to the same era by documenting, as part of a pilot project, a number of examples of stone, wood, and plaster materials that are, in many respects, comparable to other instances of Islamic Egyptian history.

By adopting this research, Egypt's heritage buildings can be made accessible as references in the proposed inclusion of a heritage facility management database, where specialists can draw on the experiences of others to inform the creation of tailor-made maintenance schedules. According to their state of deterioration, Egypt's heritage buildings are catalogued and made accessible as references in the database for future intervention at any level and for the same maintained heritage buildings or other cases.

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