Developing a Model to Improve the Efficiency of Maintenance Management for Service Buildings Using BIM and Power BI: A Case Study

Mais Subra [*,1], Fayez Jrad [2], Sanaa AL Mezawy [3]

[1] Building Information Modeling and Management Master Student, Syrian Virtual University
[2] Professor lecturer at the Syrian Virtual University
[3] Teacher assistant at the Syrian Virtual University
Emails: mais_193705@svuonline.org; t_fjrad@svuonline.org; t-salmezawy@svuonline.org

Abstract

Maintenance management has a major role in maintaining service buildings and improving their performance. Therefore, in this research, building information modeling (BIM) was applied to one of the university buildings to obtain detailed and accurate information about the building's components and link maintenance data to each element of the building through the capabilities and flexibility of the Revit program, which is reflected in the It is evident in the ability to add parameters to the elements and thus sort the maintenance data according to the elements of the building and model it to turn into information that can be extracted, analyzed and explored for the implicit knowledge in it through business intelligence techniques, to understand it and make appropriate decisions, which is reflected in the accuracy of maintenance work and achieving the best quality of service at the lowest cost. . Relying on the descriptive and analytical approach, by describing the reality of maintenance management in the Maintenance Department, describing the architectural maintenance work that took place within a period of 5 years (2019-2023), and conducting an accurate description of all the elements of the building to create a BIM model for the building of the College of Mechanical and Electrical Engineering. Then link the maintenance data with the operational data of the model by entering the maintenance parameters on the architectural elements of the building (doors - walls - windows - false ceilings - floors) and taking advantage of what Revit technology provides in creating tables specific to the building, and exporting them to Excel and then to the Power program. Bi, which provides the ability to analyze data, identify the most important maintenance problems and the maintenance cost for each item, determine the proportions of implemented and non-implemented items, determine the reasons for non-implementation, and measure the performance of workshops and specialists. In addition to achieving a spatial and visual link between the most important problems and their architectural spaces, predicting an approximate budget for future architectural maintenance in the coming year, and evaluating the building elements by giving technical marks to determine the periodic maintenance items for the next year for the door element, studying the expected cost of maintaining the doors, and determining the necessary materials to be supplied for the coming year.

Keywords: Maintenance Management; Service buildings; Building information modeling BIM; The university; Business Intelligence BI ….

1.0 Introduction

Maintenance is the process that maintains buildings with all their systems, and ensures their continued effective performance. Building information modelling allows a better understanding of the building and its components, and documents and archives the building's data. Within an information-rich

Doi : https://doi.org/10.54216/IJBES.080102
Received: April 10, 2023 Revised: September 14, 2023 Accepted: January 14, 2024

model, to improve maintenance operations, plan them in advance, and determine their priorities, and given the huge amount of data contained in the building model, which can be increased further during the investment and operation phase, the importance of using business intelligence (BI) comes, which is one of the techniques of artificial intelligence (AI).

2.0 Related Work

Several studies have dealt with the concept of maintenance, its types, and its costs, where maintenance has been defined as (a continuous process and permanent activity to maintain buildings and keep equipment in the best condition, and that it is (the third element after design and implementation that leads to a decrease in the expected life of buildings). [11]. These are operations. Which must be implemented in the operating phase of the building's life cycle to preserve it [25]. Maintenance includes the entire building with its various structural, architectural, and sanitary systems [8]. Maintenance work has also been classified into: (planned and unplanned) [1]. This helps Classification in the management of maintenance work in all its stages [19]. Maintenance costs constitute an important proportion of the costs and expenses incurred within the life cycle of the building [9]. The most important reasons leading to excess costs, represented by inefficient maintenance, are [6]. Among the most important reasons for the appearance of defects in Facilities: changing the uses of the building [3]. Neglecting maintenance work [2]. Implementation errors [4]. As well as deficiencies in administrative legislation requiring regular maintenance and leaving the building neglected until it reaches the stage of collapse. [11] Emphasis must be placed on the importance of the item for carrying out maintenance work. Preventive measures that prevent its occurrence [7]. There must also be a scientific approach to maintenance management and good use in the operation phase [14]. The performance of buildings was evaluated through several studies, including university buildings, based on the balanced performance theory [24,26]. Or by evaluating (the building area - the age of the building - the number of maintenance employees - the budget) [10] or by focusing on the performance indicator to evaluate the facility (functional, technical and sanitary) within a special model for school buildings [21]. BIM is also known as the process of generating and managing Building data during its life cycle. [15]. The application of BIM is important in the construction industry and data from publications in operation and maintenance[26-43-44-45], It is difficult to implement BIM but very necessary[23][25][26], This is particularly affecting the AEC sector, where many engineers have not had the opportunity to work on projects that are based on new technologies and methodologies[37][39][33], In addition to have a great potential to solve problems between disciplines [27-38-35-45-46-47], The advantages of BIM have been acknowledged by developed countries [28][28], can be applied to a wide range of subjects and areas [33], Despite all this, the level of BIM adoption is still much lower than expected [24]Accordingly, the Syrian educational bodies need to allocate more time and effort to qualify engineers and help them keep up with the latest technologies [41], At present, the AEC industry in Syria is experiencing a shift from CAD to BIM. It's crucial that this transition is supported by the government, relevant companies, and academic community. This will enable the industry to stay abreast with the rapidly advancing technological landscape [34], To obtain the ideal operational model for the building, which is a treasury of documents and data for the building during its life. [22]. We find problems with the traditional system in recording maintenance work and the importance of BIM in documenting data and information related to construction [16-47]. The method of recording maintenance orders for a year in order to generate a database using BIM for a three-story university building was adopted by researchers at an American university. [12]. Studies have touched on the importance of integrating knowledge management with BIM to support decision-making in maintenance by creating databases in the BIM&KM environment for the most important maintenance items in service buildings [23]. With the development of the AEC construction industry, the need has emerged to integrate artificial intelligence (AI) with BIM to make construction information more accurate and practical [40-43-44]. [27] The importance of business intelligence (BI) technology lies in the ability to follow up, predict, arrange, classify, save documents, issue reports, and follow up on business implementation. [18] and the need to extract knowledge through special techniques from old maintenance records to improve future maintenance [7]. They pointed out that Power BI business intelligence provides, through its interactive interface and through the dimensional structure of data, the ability to review, process and analyse data by creating reports that can be linked to REVIT through the Excel program. [28] [23].

Doi : https://doi.org/10.54216/IJBES.080102
Received: April 10, 2023 Revised: September 14, 2023 Accepted: January 14, 2024

3.0 Research problem

The traditional maintenance management systems currently used in university facilities lack an effective approach. We summarize the research problem as follows:
1-Is maintenance information for university buildings archived and stored electronically?
2-How can we benefit from the maintenance information that was performed for future maintenance**?**

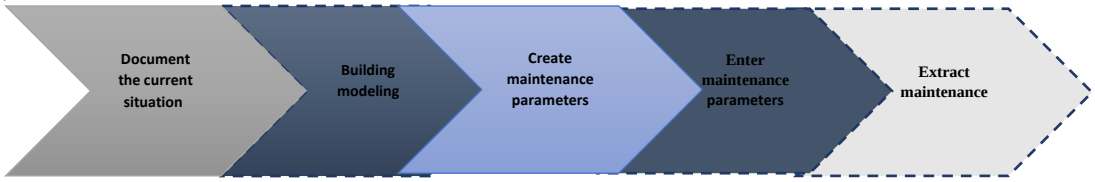
4.0 Objective and importance of research

The importance of the research comes from the fact that the maintenance process affects the life span of buildings. The research aims to model the case study using BIM (REVIT) techniques, as it is one of the most important programs that help in creating a building database that can store a huge amount of data, whether through existing parameters. Within the program, or through its flexibility in the ability to add parameters to the elements and components of the building that serve maintenance operations, and analyses the available data about maintenance using business intelligence techniques (POWER BI) with the aim of making the most accurate decisions**.**

5.0 Research methodology

(Descriptive analytical method)
A - In the first stage: modelling the facility on (REVIT), and describing the reality of the building in detail to document the current components of the building elements, taking into account accuracy in determining the technical specifications of the elements from an architectural perspective. It also includes tracking the maintenance work that was carried out over a period of 5 years and working to introduce All maintenance work data to reach a model in the BIM environment that is rich in all maintenance data for the building. Figure (1)
B - In the second stage: it depends on analysing data by exporting reports related to maintenance, and analysing them using business intelligence software, to reach the ability to make decisions Figure (2)

.



Scheme of the first stage of obtaining a BIM model (1) Figure

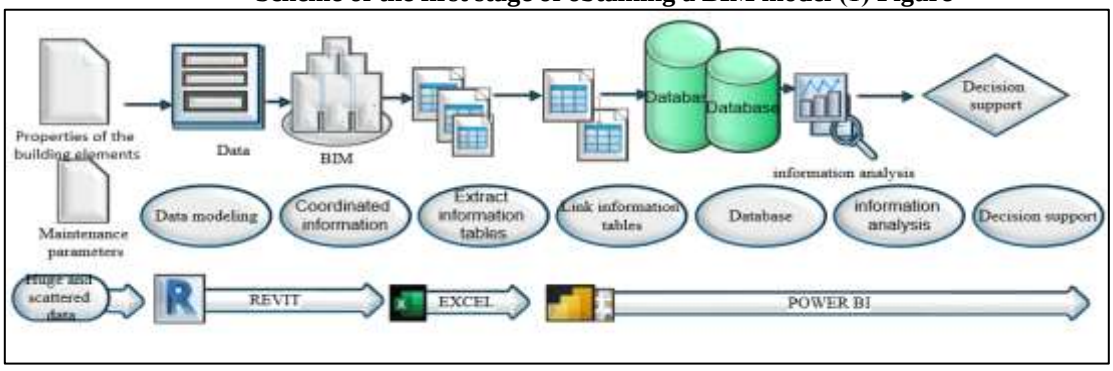


Figure 2: Diagram of the second stage to reach appropriate decisions

6.0 Case study: Creating a maintenance model for the building of the Faculty of Mechanical and Electrical Engineering at Tishreen University using BIM

6.1 Identify the architectural elements of the building

Walls (external walls, interior walls, and bathroom walls), floors ((30*30*3)) Bedrosian marble, ceilings (false ceilings), tiles 60*60, doors (wooden veneers, aluminium veneers), windows (aluminium veneers, aluminium veneers).

Doi : https://doi.org/10.54216/IJBES.080102
Received: April 10, 2023 Revised: September 14, 2023 Accepted: January 14, 2024

6.2 Determine the necessary parameters for maintenance

1. The name of the applicant	2. Date of implemting the request	3. Date of submitting the request	4. The cost of maintenance
5. Request number	6. Site number	7. Place of the element	8. Request status
9. Reasons for non - implementation	10. Maintenance classification	11. Name of the responsible for implementation	12 Description of the problem

6.3. Creating the model for the College of Mechanical and Electrical Engineering building

A model for the college was designed according to Figure (3-4-5) and maintenance parameters were entered into the model by adding maintenance parameters from Add Parameter

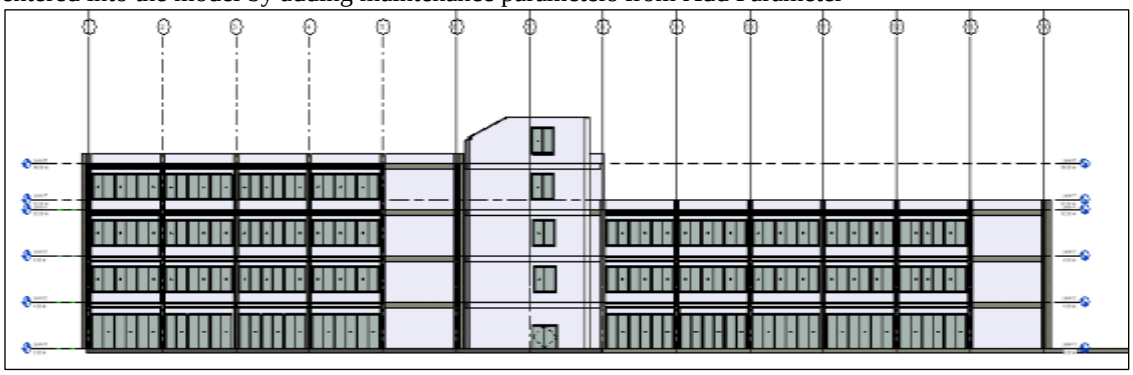


Figure 3: The southern elevation of the building

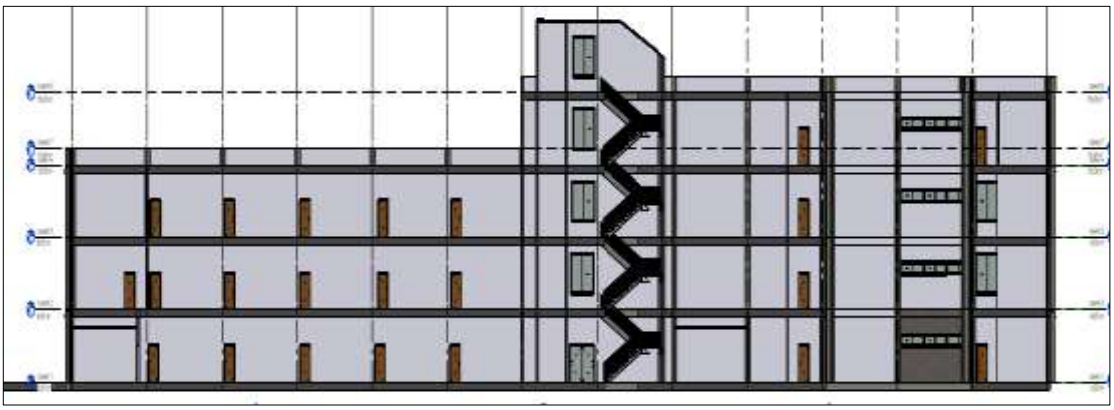


Figure 4: Section A-A

Doi : https://doi.org/10.54216/IJBES.080102
Received: April 10, 2023 Revised: September 14, 2023 Accepted: January 14, 2024

Figure 5: Detailed perspective of the Hamak College building

6.4 Create a database of maintenance items in a business intelligence environment

1) Import maintenance schedules from Excel

Maintenance data is imported (after exporting it from the Revit model to Excel) from the Get data icon, then Excel Workbook, then Connect. We choose the file name Open, and from the Navigator menu, the data tables that were exported from Revit and saved in Excel appear to form a database for building maintenance work.

2) Define truth tables and dimension tables

The main table and the sub-tables are organized using star schemas. The main table **expresses** the characteristics of the operational data of the building elements (Identity Data), which is unique and not duplicated. It is called the truth table (which expresses the data of the elements that already exist in the Revit program and that distinguish the para-objects. Metric) The operational data table includes the following columns (Height-Family and type-family-… Mark-). We note that the Mark column is the unique column in the operational data table. As in Figure (6)

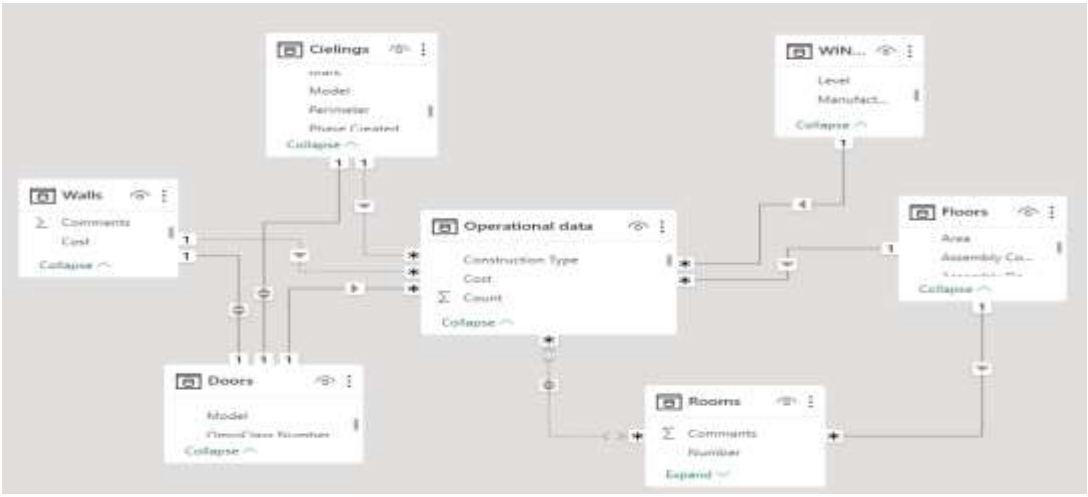


Figure 6: Linking the truth table with the dimension table

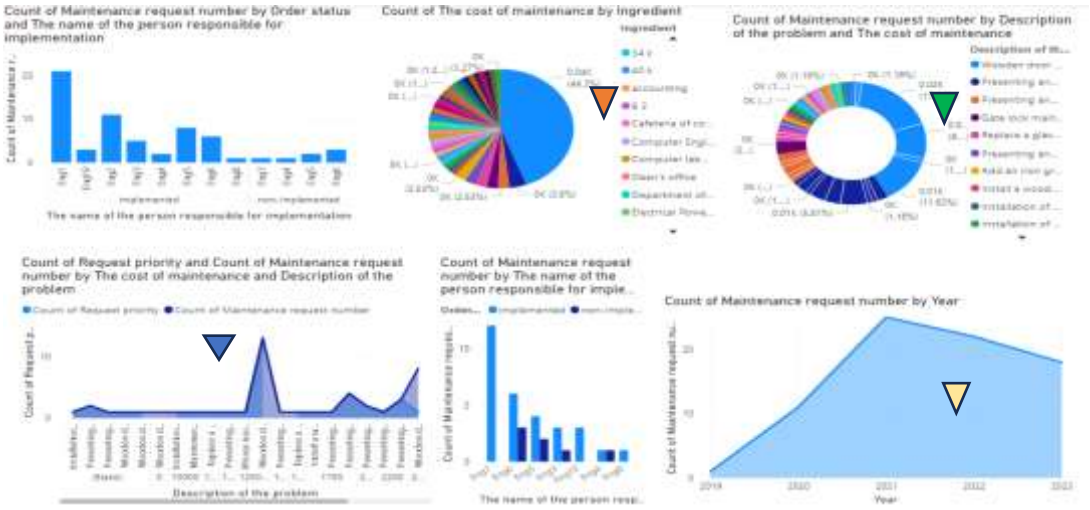
7.0 Analyse maintenance data in a business intelligence environment

7.1 At the level of building elements:

Figure (7) shows an interactive interface in Power Bi for doors through which we notice that the number of maintenance requests ranges between 18-22 requests per year due to the lack of opening

Doi : https://doi.org/10.54216/IJBES.080102
Received: April 10, 2023 Revised: September 14, 2023 Accepted: January 14, 2024

new specializations, while we notice that in 2019 the percentage of requests was 5-20 requests due to the transfer of the Engineering Institute to the Hamak building. The most important problems that make doors need maintenance, the most important of which is the maintenance of bathroom doors, which constitute 36% of the number of requests, due to problems with plumbing installations, frequent use, and lack of continuous care, in addition to the type of materials used in painting the doors, which do not achieve good insulation. We also note that the problem of locks constitutes 20%. From the number of maintenance requests, the locks used are of the cylinder type. The cost of maintaining wooden doors constitutes the highest cost at 50.3% of the maintenance cost of doors. The installation of iron doors constitutes 24%, and they are placed for security reasons and to preserve assets. We note that the number of maintenance requests is concentrated in the bathroom area at a rate of 35.38% due to problems with sanitary installations, frequent use by students, and lack of continuous maintenance, followed by student affairs at a rate of 21.68% due to the opening of new rooms affiliated with student affairs and due to the increasing number of students, followed by the Engineering Institute Department at a rate 9% due to the increasing need for investment



.

Figure 7: Interactive interface for doors

Table 1: Maintenance data at the element level

Element	Number of maintenance requests	The percentage of maintenance cost	The percentage of the problem according to repetition	The percentage of the problem by cost	The percentage of the problem according to the void	The void according to the number of requests
the doors	86	34%	36%	50.30%	35%	bathroom
Walls	48	26%	50%	58.30%	58.30%	bathroom
Windows	23	12.49%	43%	32%	43%	B m
Bishop	15	16.72%	31%	44%	24%	Dean's office
Floors	3	5.45%	100%	41%	100%	bathroom

In the same steps, the rest of the data for other elements: walls, floors, false ceilings, and windows are analyzed in Table (1).

Doi : https://doi.org/10.54216/IJBES.080102
Received: April 10, 2023 Revised: September 14, 2023 Accepted: January 14, 2024

7.2 Analyze maintenance data in a business intelligence environment at a building-level

Implementation cost:
We note that the cost of maintaining doors constitutes 34.35% of the maintenance cost, then walls at 26%, then windows at 17.4%, then false ceilings at 16.72%, and the cost of maintaining floors at 5.4% Figure (9)
.

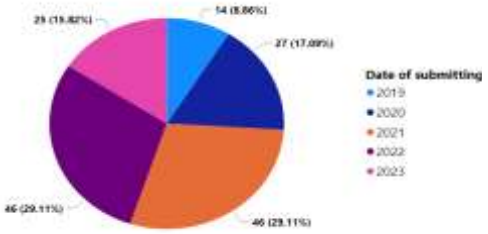


Figure 9: Distribution of maintenance costs among the various elements of the building

Excution percentage:
The percentage of completed works reached 88.5% of the total requests, and the percentage of unimplemented requests reached 11.4% for financial reasons (lack of budget) or technical reasons (lack of workshops) Figure .(8)

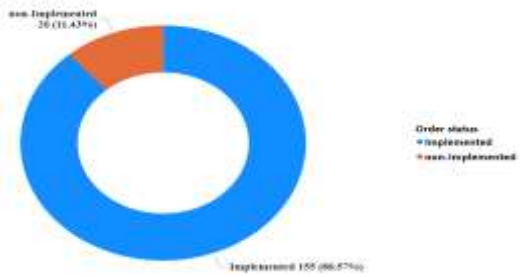


Figure 8: Ratio of emplement to non-emplemented works

7.3 Identify the most frequent maintenance problems

To determine the most important maintenance problems in terms of problem frequency, the Pareto principle (20/80) can be followed, which states that about 80% of damage or losses in factories are caused by 20% of the problems or causes. These reasons, which are few in number, are considered important and influential, and therefore, if they are avoided, production quality and economics will improve. Figure (10) Maintenance problems frequency chart

We conclude from the plan the most important maintenance problems: maintaining a wooden door - maintaining ceramic walls - providing and installing a lock, painting a wall - installing a false ceiling - replacing a glass panel - providing and installing an iron door.

To determine the most important maintenance problems in terms of problem frequency, the Pareto principle (20/80) can be followed, which states that about 80% of damage or losses in factories are caused by 20% of the problems or causes. These reasons, which are few in number, are considered important and influential, and therefore, if they are avoided, production quality and economics will improve. Figure (10) Maintenance problems frequency chart

We conclude from the plan the most important maintenance problems: maintaining a wooden door - maintaining ceramic walls - providing and installing a lock, painting a wall - installing a false ceiling - replacing a glass panel - providing and installing an iron door.

Doi : https://doi.org/10.54216/IJBES.080102
Received: April 10, 2023 Revised: September 14, 2023 Accepted: January 14, 2024

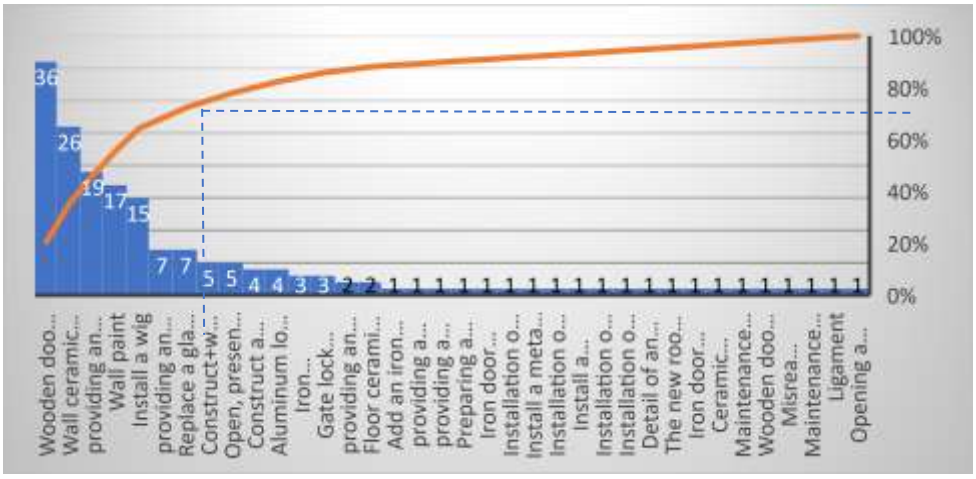


Figure 10: Maintenance problems frequency chart

7.4 Statistical analysis of the implementation time of maintenance items

Request execution time T(x) = request execution time t1 – request submission time t0
Duration of carrying out wooden door maintenance: We calculate the total time periods for the wooden door maintenance item and divide by their number $T(x) = \sum_{n=1}^{n}(t_1 - t_0)$ There is a delay in implementing requests in general, especially the carpentry and blacksmith workshops, and therefore the performance of the workshops must be improved (Table 2).

Replacement of glass panel	Providing and installing an iron door	Installing a false ceiling	Wall paint	Provide and install a lock	Wall ceramic maintenance	Wooden door maintenance	the problem
80 Day	Day 175	Day 265	Day 115	Day 57	107 Day	114Day	Duration of implementation

7.5 Statistical analysis of the cost of maintenance items:

Maintenance costs for the most important maintenance items, where the percentage of maintenance costs for wooden doors is 27.85% of the total costs, then the cost of installing false ceilings is 26.5%, then maintaining wall ceramics is 24.5%, then installing iron doors is 13.5%, painting walls is 4%, then replacing glass panels is 2%. % Figure (11). Given the heterogeneity of costs due to price differences and their constant change as a result of economic conditions during the five years, it was necessary to determine the cost of maintenance work for each year according to the following**:**

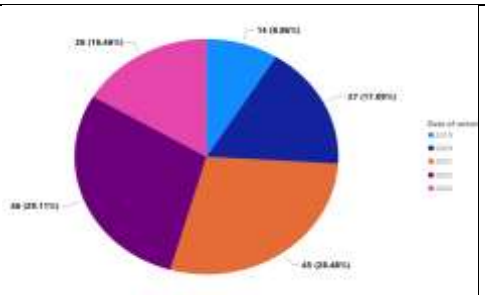


Figure (12) Annual maintenance costs for each year

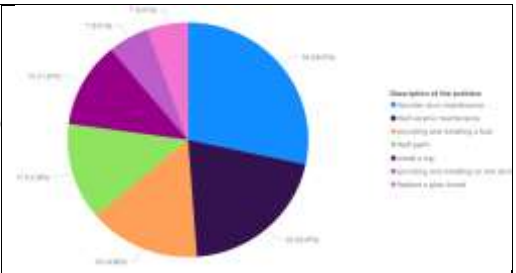


Figure (11) Cost of maintenance items

Maintenance costs during the five years from 2019-2023, indicating that the costs for the year 2023 until the end of May, Figure (12).

Doi : https://doi.org/10.54216/IJBES.080102
Received: April 10, 2023 Revised: September 14, 2023 Accepted: January 14, 2024

7.6 Approximate budget forecast:

It is also possible, through the Power BI program, to use the relationship between the cost of maintenance in the college and the number of college students in the same year to predict the approximate budget needed to maintain a college with a specific number of students, as the correlation coefficient between the cost and the number of students was strong (0.93), and Figure (13) shows the relationship between the cost of college maintenance and the number of its students

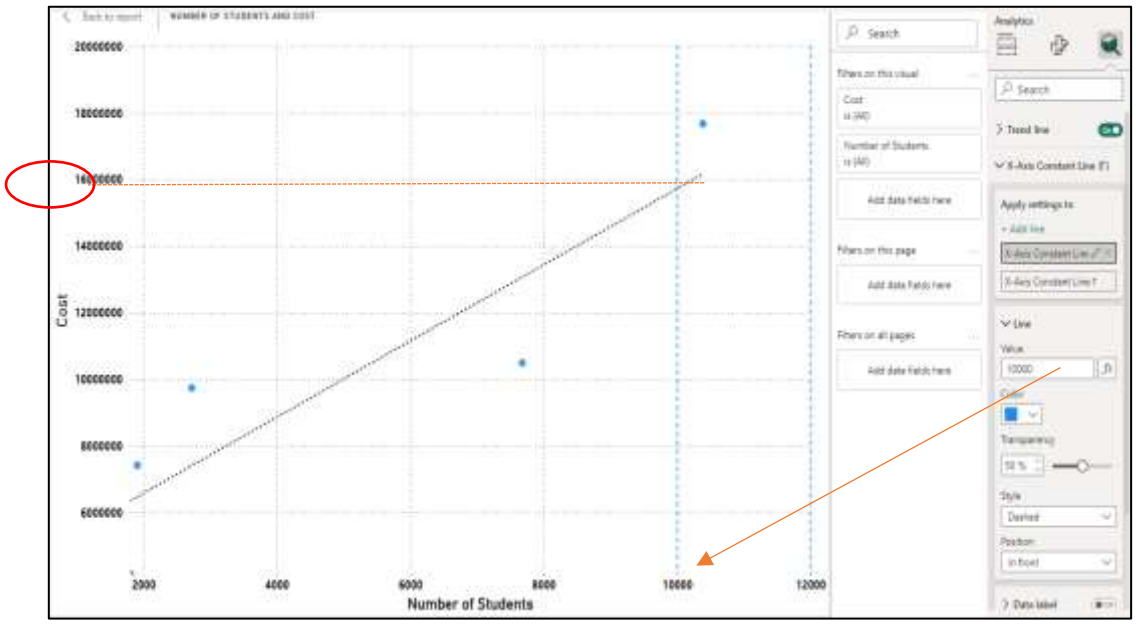


Figure 13: Approximate budget forecasting chart

If the number of students in the next academic year is 10,000 students, the approximate expected budget is about 16,000,000 SYP, which must be multiplied by the inflation factor corresponding to the year of calculating the budget as follows: Inflation factor in the year x= (exchange rate of the dollar in the year x /1800), where /1800/ is average. The dollar exchange rate in 2019, the year of data collection, and assuming the inflation factor for the year 2024 (12600/1800 = 7), the approximate budget for the maintenance of Al-Hamak College in 2024 = 16,000,000*7 = 112,000,000 SYP

7.7 Conduct door element evaluation

Determining the technical signs of the severity of the condition of the door element, the specific condition standard for evaluating the condition of the elements (Choka, 2012

Table 3: evaluation of doors

Final cost	Cost of maintenance					Evaluate and describe the problem					Evaluation score	the count	Maintenance Type
	Replacement and installation of internal	Replacement and [illegible]	Painting with scratching and kneading x3	Replacement grip x2	Replacement lock x1	Quality of clothing	Quality material	Paint quality	Quality of grips	Quality locks			
$X_1+X_2+X_3+X_4$	0	X_4	X_3	X_2	X_1	0	0	0	0	1	1	16	replacing
$X_1+X_2+X_3$	0	0	X_3	X_2	X_1	0	0	0	1	1	2	22	Maintenance is critical

Doi : https://doi.org/10.54216/IJBES.080102
Received: April 10, 2023 Revised: September 14, 2023 Accepted: January 14, 2024

X_1+X_2	0	0	0	X_2	X_1	0	0	1	1	1	3	30	Periodic maintenance
X_1	0	0	0	0	X_1	0	1	1	1	1	4	27	Minor maintenance

Through the following equation, we can predict the budget required to maintain the door component for the coming year, Table (3)

$$\textbf{budget} = \sum \boldsymbol{n_1} * (\boldsymbol{X_1} + \boldsymbol{X_2} + \boldsymbol{X_3} + \boldsymbol{X_4}) + \boldsymbol{n_2} * (\boldsymbol{X_1} + \boldsymbol{X_2} + \boldsymbol{X_3}) + \boldsymbol{n_3} * (\boldsymbol{X_1} + \boldsymbol{X_2}) + \boldsymbol{n_4} * (\boldsymbol{X_1})$$

$\boldsymbol{X_3}$= The cost of painting Door frame	$\boldsymbol{n_3}$=Number of doors with a rating of 3	$\boldsymbol{X_1}$= The cost of providing and installing a lock	$\boldsymbol{n_1}$=Number of doors with a rating of 1
$\boldsymbol{X_4}$= The cost of providing and installing wood	$\boldsymbol{n_4}$=Number of doors with a rating of 4	$\boldsymbol{X_2}$= The cost of providing and installing a grab	$\boldsymbol{n_2}$=Number of doors with a rating of 2

8.0 Results

• A BIM model was created for the building of the Faculty of Mechanical and Electrical Engineering using the REVIT program as a step to model the rest of the faculties of Tishreen University, which share the characteristics of the building components. Parameters were also created for maintenance items for the building elements, and data for architectural maintenance was entered (walls - doors - windows - false ceilings - floors).)

• Determine the ratio of executed works to non-executed works, along with identifying the reasons for implementation, which are financial reasons related to insufficient budget and technical reasons related to the lack of efficient workshops. The data was also analyzed to arrive at the cost of maintenance work (doors - walls - windows - false ceilings).

• The most important maintenance problems were also identified within 5 years to focus efforts on mitigating them in future maintenance according to the Pareto principle - maintaining a wooden door - maintaining ceramic walls - providing and installing a wall paint lock - installing a false ceiling - replacing a glass panel - providing and installing an iron door

• Through the Power BI program, the relationship between the cost of maintenance in the college and the number of college students in the same year was also used to predict the approximate budget for the next year and calculate an approximate budget for maintaining the doors element.

9.0 Recommendations

After completing the research, we recommend using BIM to improve the maintenance performance of buildings through:

Electronic archiving of the entire Tishreen University buildings using the REVIT program and maintenance requests within the implemented BIM models. Linkage between building data and maintenance data to obtain a database for each building, in addition to the possibility of visual linkage between projections and maintenance requests. Benefiting from maintenance data in identifying the most important and most frequent defects and identifying them. The spaces most in need of maintenance, in order to perform periodic maintenance on them, predict the maintenance budget in the next year's plan for each building at the university, evaluate the components that make up the building, and determine the items according to the type of maintenance that it needs to facilitate the maintenance process at the university level. Determine the necessary materials

Doi : https://doi.org/10.54216/IJBES.080102
Received: April 10, 2023 Revised: September 14, 2023 Accepted: January 14, 2024

10.0 References

[1] Seely, I.H.1987. Building Maintenance. London, Second Edition.470p.
[2] Hawass, Zaki. Building diseases.(1992). Egypt, World of Books, first edition, 54 pages. (Arabic version)
[3] Abu Al-Majd, Sharif. (1993). Cracking in concrete structures and methods of treating them. Egyptian Universities Publishing House - Al-Wafaa Library, Egypt, 143 pages. (Arabic version)
[4] - Menoun, Muhammad Suleiman. (1996). Residential building maintenance. Master's thesis, Egypt, 150 pages. (Arabic version)
[5] Saladin, Wael. (1997). An approach to improving maintenance efficiency in hotels through evaluating actual performance after occupancy. Egypt University of Science and Technology.20 p. (Arabic version)
[6] Al-Khatam, J.(2003). Buildings Maintenance Cost. Master Thesis, King Fahd University of Petroleum & Minerals, 66P
[7] Reffat,R; Gero,J; Peng, W.(2004). Using Data Mining on Building Maintenance During the Building Life Cycle. University of Tasmania, Australia,91-97.
[8] Bin Akasha. (2007),Generic Process Model for Maintenance Management of School Buildings, Malaysia University, 92p
[9] Chanter, B; Swallow. (2007) . Building Maintenance Management. 2nd. Blackwell Publishing. USA, 313p.
[10] Abdulateef ,O.A. (2008). Building Maintenance in Malaysia.207-214.10
[11] Abdel Sabour, Manar. Hosni, Abdul Hadi. Issawi, Ahmed. Naseer, Ibrahim. (2009), Maintenance of residential facilities in the Arab Republic of Egypt between reality and hopes. Doctoral thesis at Ain Shams University. 472 pages.
[12] Akcamete, A; Akinci, B. (2010). Potential Utilization of Building Information Models for PlanningMaintenance Activity. Carnegie Mellon University, USA,7P.
[13] Al-Nadawi, Abdul Aziz. (2011). Business Intelligence is an advanced methodology for developing administrative processes in business organizations. Journal of Financial and Commercial Studies, Issue 2, 26 pages. (Arabic version)
[14] Hadad,Ruba, ; Hassan, Bassam. (2011), Developing a methodology to analyze the factors affecting the maintenance costs of hospitals, Master's thesis, Tishreen University, 115 pages. (Arabic version)
[15] Eastman, C; Teicholz, P; Sacks, R; & Liston, K,(2011). BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors, John Wiley & Sons15
[16] Wang, Y; Chen, H. (2011). A 3-dimensional Visualized Approach for Maintenance and Management of Facilities. Information and Computational Technology, 468-47516...
[17] Choka ,D.G. (2012);Study on The Impact of Management System on Maintenance Condition of Built Facilities(Case Study of Public Universities in Kenya).June , ,76p17
[18] Abdel Rahman, Hisham. Eid, Muhammad. Abdul Karim. (2013), A proposed methodology for the maintenance of basic general buildings in Egypt. Assiut University Journal of Engineering Sciences, Volume 41, Issue 1, January 257-289. (Arabic version)18
[19] Lopes,I, H.(2016). Requirements Specification of a Computerized Maintenance Management System-Case Study268-273.
[20] Al-Hassan, Basil; Jarad, Fayez. (2016), Improving maintenance management for government buildings using building information modeling (BIM) techniques, Master's thesis, Tishreen University, 133 pages(Arabic version)
[21] Ibrahim, Reham. Arja, Muhammad. (2017). Developing a system to manage the school building maintenance process based on performance indicators. Master's thesis, Tishreen University, 164 pages(Arabic version)
[22] Ahmed, Sonia; Saleem, Omar (2018), The Way to BIM, Guide for Individuals and Companies, Dar Al-Kutub Al-Ilmiyyah for Publishing and Distribution, 151 pages. (Arabic version).
[23] Shaban, M.H. and Elhendawi, A.,(2018). Building Information Modeling in Syria: Obstacles and Requirements for Implementation. International Journal of BIM and Engineering Science, 1(1).
[24] Yusof, N., Ishak, S. & Doheim, R., 2018. An Exploratory Study of Building Information Modelling Maturity in the Construction Industry. International Journal of BIM and Engineering Science, 1(1), pp. 6-19.

Doi : https://doi.org/10.54216/IJBES.080102
Received: April 10, 2023 Revised: September 14, 2023 Accepted: January 14, 2024

[25] Elhendawi, A.I.N., 2018. Methodology for BIM Implementation in KSA in AEC Industry. Master of Science MSc in Construction Project Management), Edinburgh Napier University, UK.

[26] Elhendawi, A., Omar, H., Elbeltagi, E. and Smith, A.,(2019). Practical approach for paving the way to motivate BIM non-users to adopt BIM. International Journal of BIM and Engineering Science, 2(2), pp.1-22.
[27] Banawi, A., Aljobaly, O., & Ahiable, C. (2019). A comparative review of building information modeling frameworks. International Journal of BIM and Engineering Science, 2(2), 23-48.
[28] Elhendawi, A., Smith, A. & Elbeltagi, E., 2019. Methodology for BIM implementation in the Kingdom of Saudi Arabia. International Journal of BIM and Engineering Science, 2(1), pp. 1-21.
[29] Al-Hassan, Basil; Omran, Jamal, Jarad, Fayez. (2019), Developing a system to support maintenance decisions in service buildings with an integrated methodology between knowledge management and BIM, PhD thesis, Tishreen University, 171 p. (Arabic version)
[30] Al-Mazawi, Sanaa; Jarad, Fayez. Mia, Rana.(2019). Proposing a model for monitoring and evaluating the actual performance of managing the building maintenance process in public universities according to the theory of balanced performance (the case of Tishreen University) Tishreen University Journal, Engineering Sciences, Volume (41), Issue 4, 317-339. (Arabic version)
[31] Morais ,G.A ; Casado,A.(2019). Building Maintenances Management Activities in A Public Institution . University de Pernambuco , Brazil .October,85-103 .
[32] Al-Mazawi, Sanaa; Jarad, Fayez. Mia, Rana. (2020). Improving the efficiency of maintenance management in public universities through evaluating actual performance. Master's thesis, Tishreen University, 180 pages
[33] Hamma-adama, M., Kouider, T. & Salman, H., (2020). Analysis of barriers and drivers for BIM adoption. International journal of BIM and engineering science, 3(1), pp. 18-41.
[34] Salamah, Taher, Shibani, Abdussalam, Alothman, Kheder: Improving AEC Project Performance in Syria Through the Integration of Earned Value Management System and Building Information Modelling: A Case Study, International Journal of BIM and Engineering Science, Vol. 5, No. 1, pp:75.
[35] Safour, R., Ahmed, S. & Zaarour, B., (2021). BIM Adoption around the World. International Journal of BIM and Engineering Science, 4(2), pp. 49-63.
[36] Zaarour, B. & Maihoub, N.(2021). Effect of needle diameters on the diameter of electro spun PVDF nanofibers. International Journal of BIM and Engineering Science, pp. 26-32.
[37] Salami, H. & Alothman, K.,(2022). Engineering Training and its Importance for Building Information Modelling. International Journal of BIM and Engineering Science, 5(1), pp. 41-60
[38] Roumieh, N. & Ahmed, S. (2022). Adopting Risk Management Professional Methodologies as an Effective Strategy to Protect Heritage Sites in Syria, International Journal of BIM and Engineering Science, Vol. 5, No. 1, pp: 61-72.
[39] Saada, M. & Aslan, H. (2022). The effectiveness of applying BIM in increasing the accuracy of estimating quantities for public facilities rehabilitation projects in Syria after the war, International Journal of BIM and Engineering Science, 5(2), pp: 08-18
[40] Mashali, A. & El tantawi, A.,(2022). BIM-based stakeholder information exchange (IE) during the planning phase in smart construction megaprojects (SCMPs). International Journal of BIM and Engineering Science, 5(1), pp. 08-19.
[41] Dalloul. F. & Saod. Lama,(2023). Proposing a framework for introducing the concept of engineering digitization to develop curricula: case study - Tishreen University, Faculty of Civil Engineering. International Journal of BIM and Engineering Science (IJBES) Vol. 06, No. 01, PP. 34-51, 2023
[42] Al Mezawy,S; Jrad,F;Maya,R.(2023).Methodology to Improve Efficiency of Maintenance Management for Service Building Using Business Intelligence .Damascus University Journal for The Engineering Sciences ,12.
[43] Saleh ,F, H., Elhendawi , A Darwish.A,S. and Farell, P.,(2024). An ICT-based Framework for Innovative Integration between BIM and Lean Practices Obtaining Smart Sustainable Cities. Al-Rasheed International Private University International Journal of BIM and Engineering Science, 2(2), pp.68-75.
[44] Fawaz Saleh, Ashraf Elhendawi, Abdul Salam Darwish, Peter Farrell. (2024). A Framework for Leveraging the Incorporation of AI, BIM, and IoT to Achieve Smart Sustainable Cities. Journal *of Journal of Intelligent Systems and Internet of Things*, 11 (2), 75-84 (**Doi:** https://doi.org/10.54216/JISIoT.110207)

Doi : https://doi.org/10.54216/IJBES.080102
Received: April 10, 2023 Revised: September 14, 2023 Accepted: January 14, 2024

[45] Evans, M., Farrell, P., Elbeltagi, E., Mashali, A. and Elhendawi, A., 2020. Influence of partnering agreements associated with BIM adoption on stakeholder's behaviour in construction mega-projects. *International Journal of BIM and Engineering Science*, *3*(1), pp.1-20

[46] Elgendi, A.F., Elhendawi, A., Youssef, W.M.M. and Darwish, A.S., 2021. The Vulnerability of the Construction Ergonomics to Covid-19 and Its Probability Impact in Combating the Virus. *International Journal of BIM and Engineering Science*, *4*(1), pp.01-19.

[47] Ahmed, S., Dlask, P., Selim, O. and Elhendawi, A., 2018. BIM Performance Improvement Framework for Syrian AEC Companies. *International Journal of BIM and Engineering Science*, *1*(1), pp.21-41

Doi : https://doi.org/10.54216/IJBES.080102
Received: April 10, 2023 Revised: September 14, 2023 Accepted: January 14, 2024