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Application Innovation Strategy For Digital Maintenance Management Of School Building In Iraq

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Abstract

The project generates huge amounts of data during its life cycle, and the multiplicity of construction teams leads to the occurrence of the so-called information island, which causes the loss of basic information in the operation and maintenance phases, and increases the time and cost to access the required data, as the teams responsible for maintaining and managing facilities face a major challenge. because these teams cannot find or use the information, they need to manage this building, after completing the implementation process, we get full of engineering plans and various types of documents related to the design and implementation phases, and these data and information in paper form are difficult to communicate to the teams responsible for maintenance and are exposed to loss, the study's purpose ,develop a system the merge various severity factors in order identify prioritizing maintenance of elements the building by using Risk-Based Maintenance (RBM) ,develop a central warehouse include to data entry, format, editing, storing, and updating during life cycle of the project to help maintenance engineers for implementing correct management of this information and ensuring that all data are available to assist in the correct implementation of operational and maintenance work , integrate BIM with cloud storage application by user interface, and data access to provide a better system and environment for digital building maintenance systems. which prompted the development of a maintenance system which including create 3D model, the work flow of information, automated and digital the elements of the model, communication protocols and security and design cloud storage framework that allows data to be standardized into a single form. this model is used for visualization and collaboration during design, construction and operations and maintenance work that is used to produce living breathing of project, using school building as case study to cover two methodologies given as risks and assessment severity, it is based on the level of risk and equations an assessment severity and probability of elements if maintenance is not performed, and ranks them in order of priority. The study's findings may be utilized by government institutions and maintenance engineers to get a better knowledge of the application and execution of maintenance systems in Iraq.

Keywords: Risk-Based Maintenance, integrate BIM with cloud computing, visualization and collaboration at all levels of project

INTRODUCTION

Building maintenance is a practice that attracts a lot of attention around the world. The appropriate management of maintenance aids in the preservation of capital as well as the health and safety of those who use the facility, During the life cycle of a building, the greatest expenses are

incurred during the operation and maintenance stages, which account for roughly 60% of the total cost, conventional traditions, and inefficiencies in getting important operation and maintenance (O&M) information are major concerns when it comes to keeping facilities in good working order. Furthermore, today's structures are becoming increasingly complex. Managing built facilities necessitate a wide range of actions and data. As a result, having quick access to information is critical for running and maintaining a facility. Unlike the design and building phases, the information required for O&M is required throughout the facility's existence**.**

Some of the primary issues include the accessibility, availability, and trustworthiness of accurate information throughout the lifecycle of a construction project. There is no framework for managing the lifecycle information of a building project. Furthermore, there is a lack of understanding of the challenges that arise during the lifecycle of a facility. As a result, issues such as operation, maintenance, environmental effect, and commissioning are not given the attention they deserve many authors believe that the lack of information interoperability on the delayed adoption of technology innovations, result in the design, engineering, construction, and operation and maintenance have lagged in technical innovations**.**

Furthermore, the construction industry's fragmented character has prohibited the integration of all needed information throughout the building lifecycle. This fragmentation adds to the time and effort required to respond to project difficulties quickly and effectively. To tackle this fragmentation

Despite the paramount importance of maintenance operations, the concerned authorities do not give them enough attention, as so far there is no specific system to carry them out, it is necessary to lay the foundations for the organization of maintenance work. This problem is generally present in building maintenance in Iraq, and it is evident in school buildings, although, there is a similarity in the models of these schools that increases the possibility of organizing this system in a way that provides great facilitation for engineers in this field**.**

The real obstacle to this issue is the following points **:**

•There is no unified system and method for maintenance approach and their components

•Absence of planning within maintenance operations, in terms of not setting priorities

•Errors caused by humans

•Transmission of the information is disrupted

•Decision-making is hampered by a lack of data**.**

•Costly software licensing

Literature Review

To maintain the upkeep and operation of buildings, a maintenance program that encompasses maintenance, repair, and renovation must be established to suit the difficulties and demands of the maintenance buildings. Repair or renovation of building is necessary as they age to provide adequate upkeep. It is, however, difficult

to repair or rebuild every single building in each area of country.[1]

This is apparent in the case of Iraqi public schools, which have seen an increase of 80 percent in maintenance costs over the previous five years. Building upkeep at schools received just 5% of the overall allocation for the whole education sector in the government budget. This quantity is insufficient to meet the needed maintenance allocation, stymieing progress toward excellent maintenance management. The failure to handle upkeep in school buildings has resulted from a lack of financial resources [2].

Building upkeep is one of the most likely areas to see budget decreases certain maintenance tasks are postponed to save money or to make room for areas deemed more critical by the organizations. However, the truth is that the maintenance budget

will never meet the needed amount, hence prioritizing is used. Maintenance prioritizing is a method of addressing the issue of insufficient maintenance allocation. [3].

Facilities operations and maintenance (O&M) comprises a wide range of services, capabilities, procedures, and technologies needed to ensure that the built environment performs the purposes for which it was planned and developed. The day-to-day actions required for the building/built structure, its systems and equipment, and occupants-users to execute their intended purpose are often included under operations and maintenance. Because a facility cannot run at peak efficiency unless it is maintained, therefore the terms operations and maintenance (O&M) are used [4]

The scope of O&M comprises the activities, procedures, and workflows necessary to maintain the complete building environment, such as a school, hospital, university, commercial, or residential structure. The requirements will differ from one facility to the next. In all circumstances, O&M necessitates experienced, skilled, and well-trained management and technical personnel, as well as a well-planned maintenance program. The idea underlying the formulation of a maintenance program is frequently based on the capabilities of the O&M group. The following are the objectives of a thorough maintenance program[5]

- Repairs at a lower cost
- Reduce the number of unplanned shutdowns and repairs.
- Extend the life of building elements, hence extending the life of the facility.
- Provide safe, functional systems and facilities that satisfy the requirements for which it was built.

creation of a cloud-based BIM platform, includes Building Maintenance System (BMS) and environmental sensor information, building geometry, indoor air quality, energy generation, and consumption are examples of such data categories. It was created to integrate multiple types of building information systems and the display of front-end data in the construction process using BIM and cloud computing[8]

with a BIM model, mistakes are minimized greatly by allocating a reasonable budget, and the maintenance budget is easier to manage since a clearer maintenance plan can be constructed. When maintenance work is done with BIM, job efficiency is enhanced since equipment and flaws are checked for accuracy. Due to inconsistency in data management, which primarily relied on human-oriented handwritten documents in the traditional technique, updating maintenance data takes a long time and costs a lot of money.[6]

Maintenance issues should be dealt with as efficiently as possible by determining the type of maintenance and implementing an effective and efficient maintenance management program. As a result, there are several types of maintenance. However, the two most common forms are planned and unplanned maintenance. Preventive and routine maintenance are examples of planned maintenance, whereas emergency and corrective maintenance are examples of unplanned maintenance [7]

selecting priority factors and measuring performance are both critical components of designing and assessing a building maintenance management plan to investigate the links between selection priority factors and strategy performance measurements. nevertheless, appears to have met its objectives thanks to a reliable sourcing strategy selection factors-performance correlation methodology.[9]

Method of study

The following research methodology was used to meet the objectives of study

by preparing a questionnaire for identify factors influencing maintenance priority in buildings and major critical building elements that required routine maintenance, secondly performance and build a system for operational and maintenance to draw maintenance strategy of school building, the research methodology is summarized in Figure1

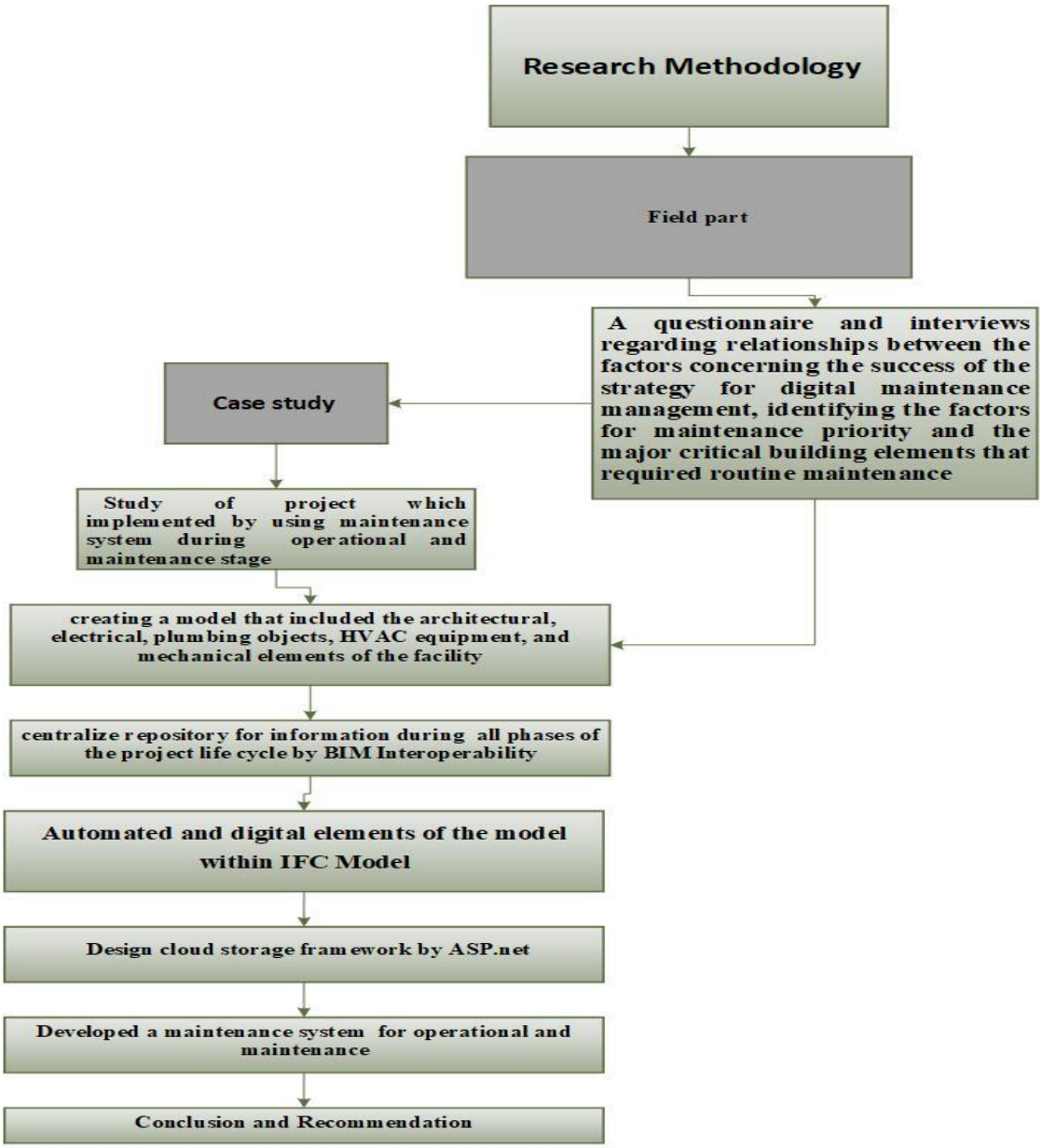

Fig. 1 Research Methodology

Create 3D model, this study used Autodesk Revit to create a BIM model, focusing on the information needed by facility managers in a BIM model by creating a model that included the architectural, electrical, plumbing objects, HVAC equipment, and mechanical elements of the facility, as well as storing information such as warranties, part numbers, manufacturer's website, and contact information in the model. The maintenance work is normally recorded on paper or using an information system by facility managers. However, referring to the typical 2D CAD-based information illustration in the maintenance is difficult for facility managers. Furthermore, information about the same maintenance work must be repeated, which is inconvenient for facility managers. To address these issues, the building information modeling (BIM) technique is used and produced as 3D information models for integrating BIM models

with work flow information in order to demonstrate the effectiveness of tracking and managing the relevant information as shown in figure 2

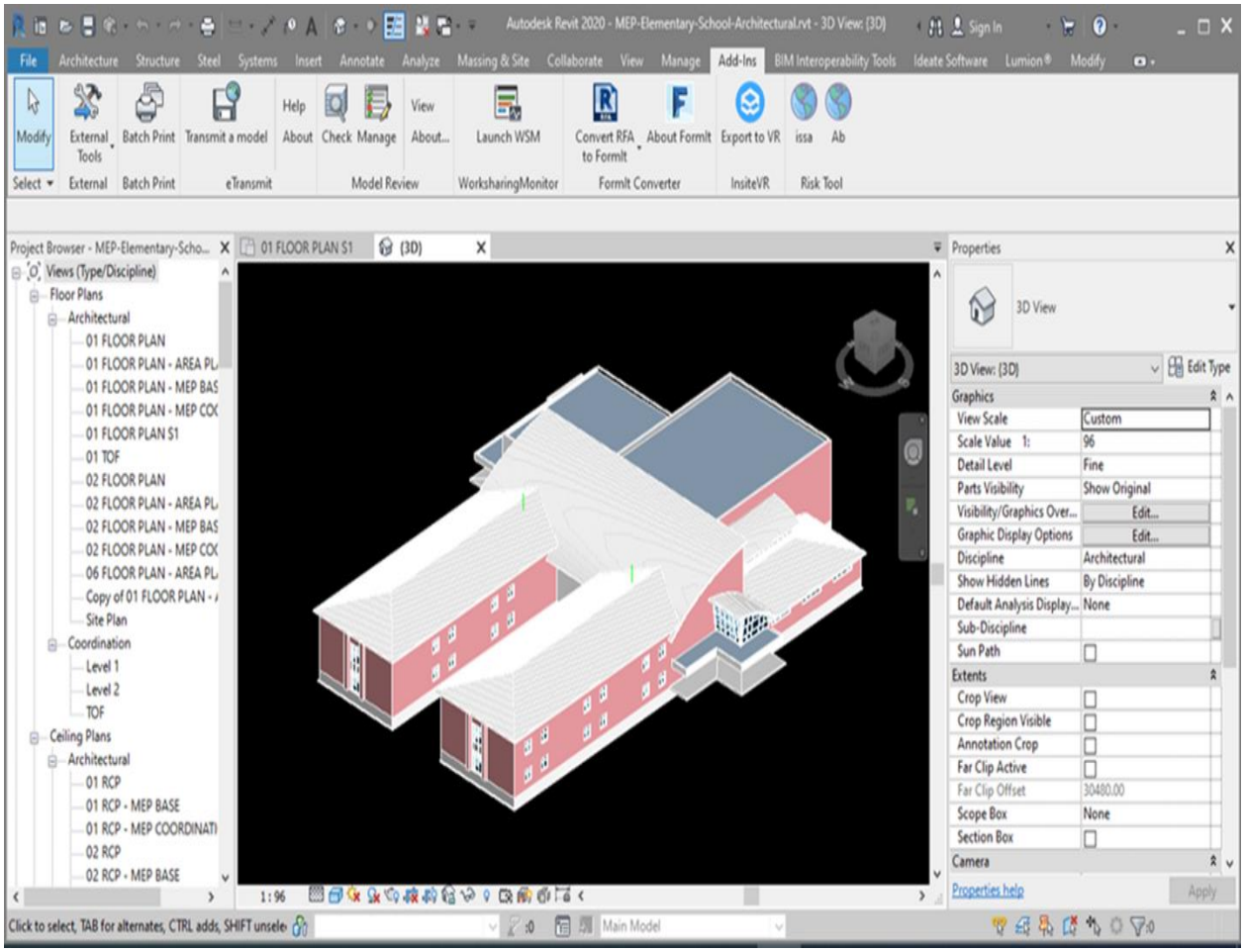

Fig. 1 3D Model for case study

The work flow of information ,a data structure for the model was developed by relying on the Cobie file and making modifications in the (Cobie) file to obtain a template that fits with the model, by adding sheets related to maintenance and operation and deleting sheets that are not intended for the management of maintenance work sheets were created and added in the (Cobie) file to match the work methodology such as component operational, system operational, component tracking, and system tracking as shown in figure 3,were also created to generate Cobie data from BIM, to generate a data-rich Cobie file automatically, we created a prototype that extracts data from Revit, a BIM tool, saves the extracted data in an external database, and then generates the Cobie file using the database information for saving facilities managers a substantial amount of time.

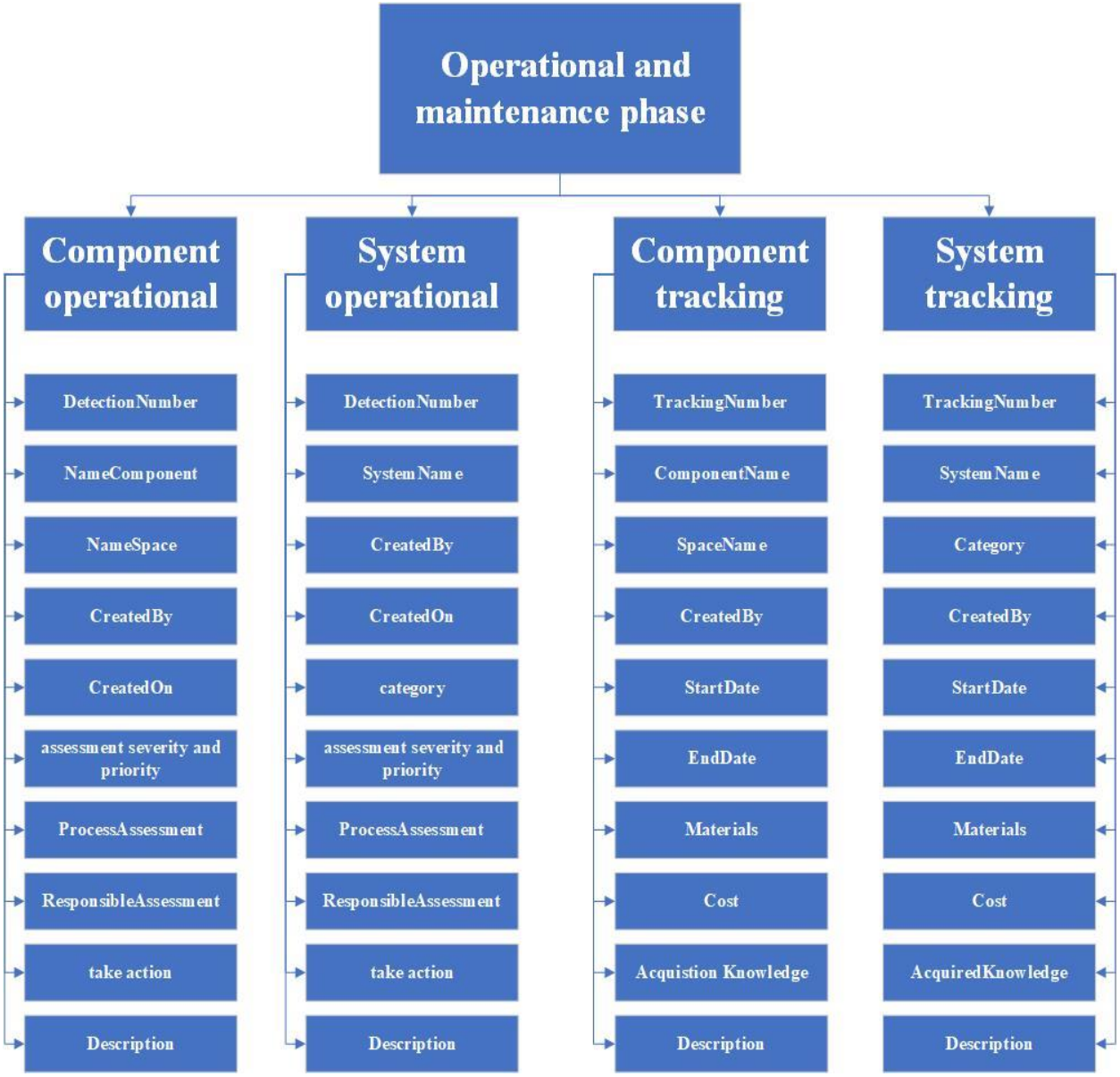

Fig. 3 Structure of information in the Operational and maintenance phase

Population factors and sampling for maintenance priorities

To accomplish the examination objective on examination of factors influencing maintenance priority in buildings, the techniques utilized were through: research plan, polls configuration, sampling of the study region, information assortment, information investigation, results, and conversation. The population under examination depended on Iraq public area and its establishments distinguish the maintenance priority isn't extraordinary, it shifts starting with one association then onto the next because of contrasts in business tasks, the culture of association, size, financial position, robotization and such. The investigation region depended on such open areas as, hospitals, schools, and universities since recognizing the maintenance priority applying to all are the equivalent however just contrast as far as execution draws near. Surveys were just circulated in different locales area. Some got surveys gave a decent picture of identifying the factors for maintenance priority,

this study has recognized 14 factors that affecting in maintenance to identify the priority for maintenance to projects in Iraq these factors have been distinguished through literature review and positioned by their general significance index by respondents rating, descriptive statistics were utilized to dissect the demographic data of the respondents while Relative Importance Index (RII) was utilized to investigate respondents' scores of the factor affecting maintenance. in this study, an ordinal estimation size of 1 to 5 was utilized to decide the impact level. Respondents were asked to rate factors affecting in maintenance priority in projects as per the level of significance as shown in Table 1.0

Table 1.0 Ranking of factors affecting in maintenance

No.	Factors	Rank	RII	Rating
1	Safety	1	0.83	Most important
2	Interruption of Operational-service	2	0.81	Most important
3	Maintenance budget	3	0.79	Most important
4	Damage of Building condition	4	0.77	Most important
5	Availability of spare part	5	0.76	Most important
6	Probability of Failure	6	0.63	important
7	The building's suitability	7	0.61	important
8	Minor upkeep	8	0.45	Less important
9	Bad weather conditions	9	0.45	Less important
10	Difficulty obtaining licenses and work permits	10	0.44	Not important
11	Lack of Legislation and Environmental Policies	11	0,40	Not important
12	Contract management	12	0.39	Not important
13	Designated waste disposal area	13	0.33	Not important
14	Complex of projects	14	0.28	Not important

Generation power of severity

Individual maintenance jobs and/or blocks of maintenance tasks are subjected to risk management principles, which are evaluated using a risk matrix. We perform maintenance because we believe it will cost us more money or have catastrophic implications if we don't. Understanding how to apply severity concepts to maintenance, as well as the processes and systems required to support decision-making, are all part of maintenance optimization.

Generating the overall severity of these selected levels is determined by Risk-Based Maintenance (RBM)[10], through calculating the overall severity of the seven factors and the equation below

Overall severity =MAX {safety level, interruption of operational service level, maintenance budget level, damage of building condition level. availability of spare part, probability of failure, the building's suitability} (Risk-Based Maintenance RPM)

Also, you can override the power of severity to align with the organization by selecting another value which set the action and assessment by the supervisor through assessing the power of the severity in terms of the consequences for your building

Generation priority of maintenance work

Then the priority level is automatically calculated by[10].

Priority Level= Power of Severity * Probability of Failure

The values of a result of priority level are categorized into the following conditions:

- Priority level < 6 means “low priority” should be addressed within one or two days.
- 6 < Priority level < 11 means “Resource dependent” It is being transferred to the maintenance department workshop.
- Priority level >11 means “Priority” will be addressed, but will likely take more than three weeks

Result by applying this tool, you will be able to rank different maintenance works against one another and guarantee that you focus and prioritize your resources to minimize the severity.

Automated and digital elements of the model

This step, which includes a database, allows the user to identify the position, ID of the element, specification, and other information to facilitate the maintenance system. The proposed system aims to create a model utilization of data by the web browser is excellent for maintenance system

This step is concerned with the transfer of data and information in the IFC format to the model produced in this study, so that it may be used as a foundation for determining the item's details for maintenance during the inspection, The element's geometrical attributes include length, breadth, height, thickness, area, volume, and so on. These characteristics can be utilized to compute the quantitative data required for maintenance work. structural features including covering thickness, coating, interlayer, and core layer thickness can also be applied to structural components. for example, if you come into a building and have seen what's above the ceiling, you may gesture to the ceiling and ask, where is the air-conditioning unit for this room

Design cloud storage framework for maintenance system

The maintenance system includes five workflow proposals: 3D, IFC model, data set Cobie, estate maintenance and interface. This system gathers all data from a building's life cycle and stores it in a cloud database. The maintenance system can then obtain those data and map them to specific purposes, 3d to create the information required by facility managers, IFC model to transfer data and information in the IFC format to facilitate inspection processes by identifying space, object properties (including material features, manufacturers, size, and installation date/period, among other things), and to differentiate the elements in a realistic picture, especially each element have its element tag

Cloud storage includes integrated data, allowing it to handle massive volumes of data and work across several devices. As a consequence, users may easily perform maintenance tasks on their mobile devices. This solution allows users to interact with each BIM element via a front-end interface in a cloud-storage environment. This method has the potential to cover a significant quantity of data. The maintenance system, for example, shows all essential information, such as prior maintenance data in digital format, when a user clicks on any element.

designing strategy for operational and maintenance

Corrective, preventative, emergency, and regular maintenance are all examples of maintenance strategies. However, there are several points of view when it comes to selecting a suitable maintenance approach. Different systems are usually available to handle data regarding building maintenance during the Operation and

Maintenance (O&M) phase of an existing building, among diverse maintenance plans. Current procedures, on the other hand, do not combine these platforms and continue to handle scattered and unformatted data manually. The goal of this study is to demonstrate the advantages of combining Building Information Modeling (BIM) with certain technical to create a maintenance system by maintenance system, the information can be mapped easily, the tag element of each building component and system is applied as the key to connect the component and system in database. In this way, the maintenance information can be exported and be directly shown in maintenance system. A user interface is developed using ASP.net and C# to visualize the maintenance system

User can directly check the condition of each component and system in the model by clicking on it. this system is shown type of facility, zone, lot number, the number of floors, department name, administration phone number, description and location (level and space), maintenance engineer can make quick enquiries of facility information and know the accurate condition of each component and system in the facility conveniently as shown in figure 4

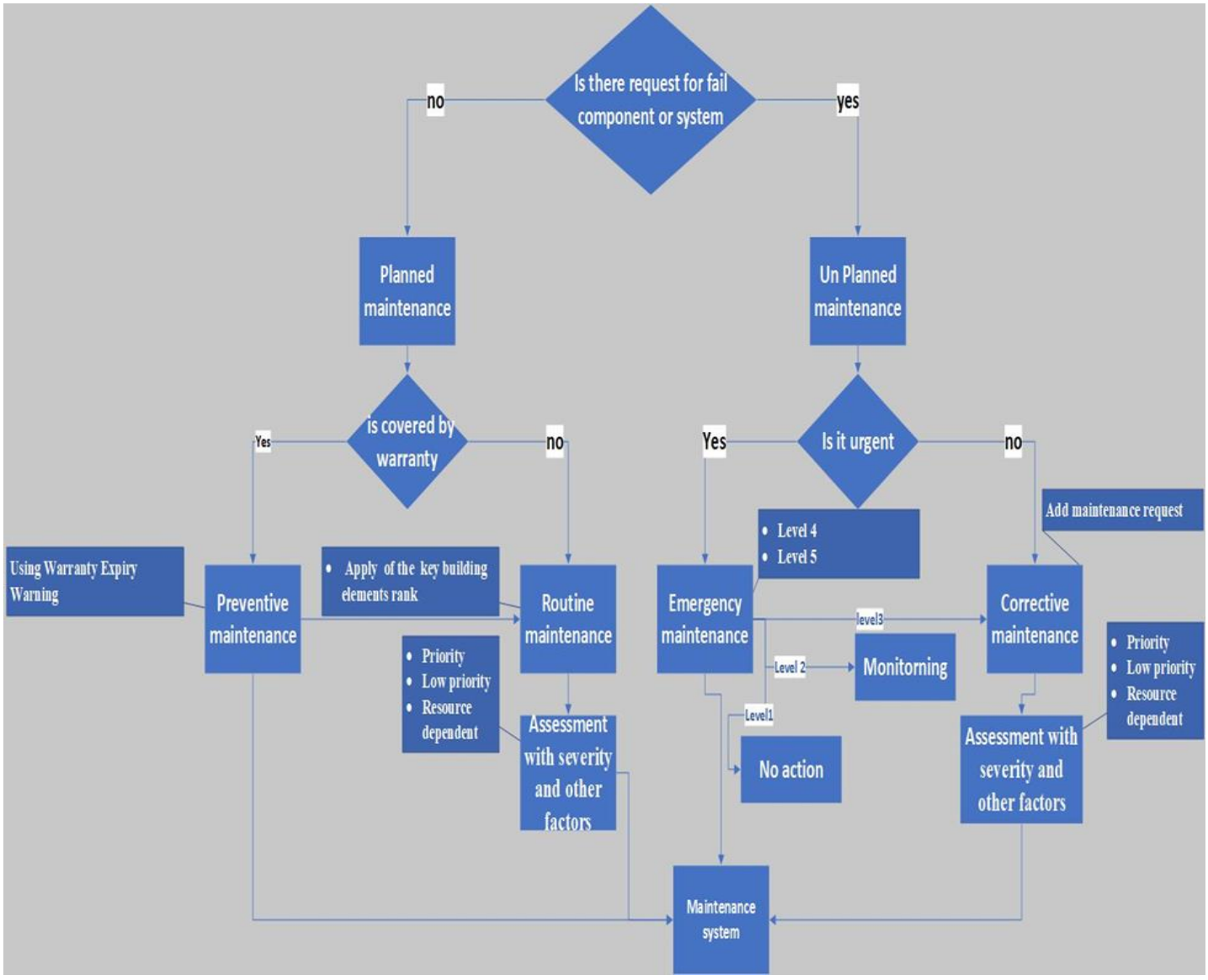

Fig.4.Case Study Flowchart (Researcher)

Results and analysis

Each school should follow the procedures for operational and maintenance strategy to meet their own needs, and to prioritize maintenance works through using a uniform and transparent strategy, to comprehend the principles of efficient school building maintenance and the significance of maintenance strategy, through reading the maintenance guideline in ministry education by researcher. This study is a tool that will assist you in prioritizing maintenance works. This study, illustrated would most likely be utilized by a maintenance engineer to plan and prioritize building maintenance work.

This study covers two methodologies given as risks and assessment severity, it is based on the level of risk and equations an assessment severity and probability of elements if maintenance is not performed, and ranks them in order of priority

A case study is done to investigate the whys and how's of the current system of maintenance management integration in a real-world setting.

In traditional maintenance, only corrective maintenance was used, and the maintenance engineer identified which elements needed maintenance and coordinated with the facility administrator to program the maintenance, which was then executed and approved, and the activities were recorded in paper-based reports. Finally, physical storage was used to store these records. As a result, time was wasted when maintenance engineers required to know the status of maintenance activities or searching through file boxes for specific information.

Based on the findings of the research study, it is required to alter the approach and create techniques and systems to address the issues with traditional maintenance processes. The adoption of a maintenance system that incorporates BIM-cloud computing information was offered to help us increase the efficacy of maintenance management, because it assists maintenance engineers in obtaining the essential information and improving maintenance activity tracking. The system was created by adopting a maintenance strategy and combining it with BIM-cloud computing. Functionalities to maintain a constant flow of information in any location and at any time

The BIM model, Cobie data, and cloud computing are the three most important inputs to the maintenance system. The first covers all of the information required by facility managers, including architectural, electrical, plumbing, HVAC, and mechanical parts of the building, as well as all of the components and systems' information.

secondly, Cobie has a lot of information for maintenance, so some major changes are made within BIM Interoperability. To add or remove some sheets from the model that are considered necessary for maintenance engineers especially during operational and maintenance stage like (Component Operational, System Operational, Component tracking, and System tracking), you must go back to Revit and update it

The Cobie connects the data in the BIM model to the Cobie standard. This indicates that the program will transfer the essential data from model elements to Cobie parameters before exporting the standard file as a deliverable (Contact, document, facility, floor, space, type, component, system, job, spare, resource, component operational, system operational, component tracking, and system tracking) are among the sheets included in the Cobie extension. The Cobie format excel sheet that is exported from the Autodesk Cobie extension is the final deliverable of the whole process. This file is critical since it communicates the design and construction information to be utilized in the operational and maintenance phase.

The third of these parameters is connected to the data and fed into the cloud computing system as a whole, the challenge is to integrate all of the information produced during the design phase, construction phase, operational and maintenance phase to maintenance engineers in single system as maintenance system

Centralized repositories are employed in the administration of cooperation approaches and allied maintenance duties. Using the data contained in these databases as shown in figure 5, one could handle problems such as maintenance planning, information gathering, computing the priority of building elements, coding, structuring the compiled data into database format, data entry

and editing, updating and acquiring knowledge from the maintenance phase and transferring it to the construction and design phases to reduce costs and errors

The basic goal of centralized repositories is to provide an easy environment for retrieving and storing database information. It works in both single-user and multi-user environments, allowed for the massive storing of pertinent data, make data access simple for designers, maintenance personnel, and construction engineers, provide a fast response to the building administrator for maintenance requests and building element repairs. Allow for numerous users to be active at the same time. Keep the data safe against unwanted access as shown in figure

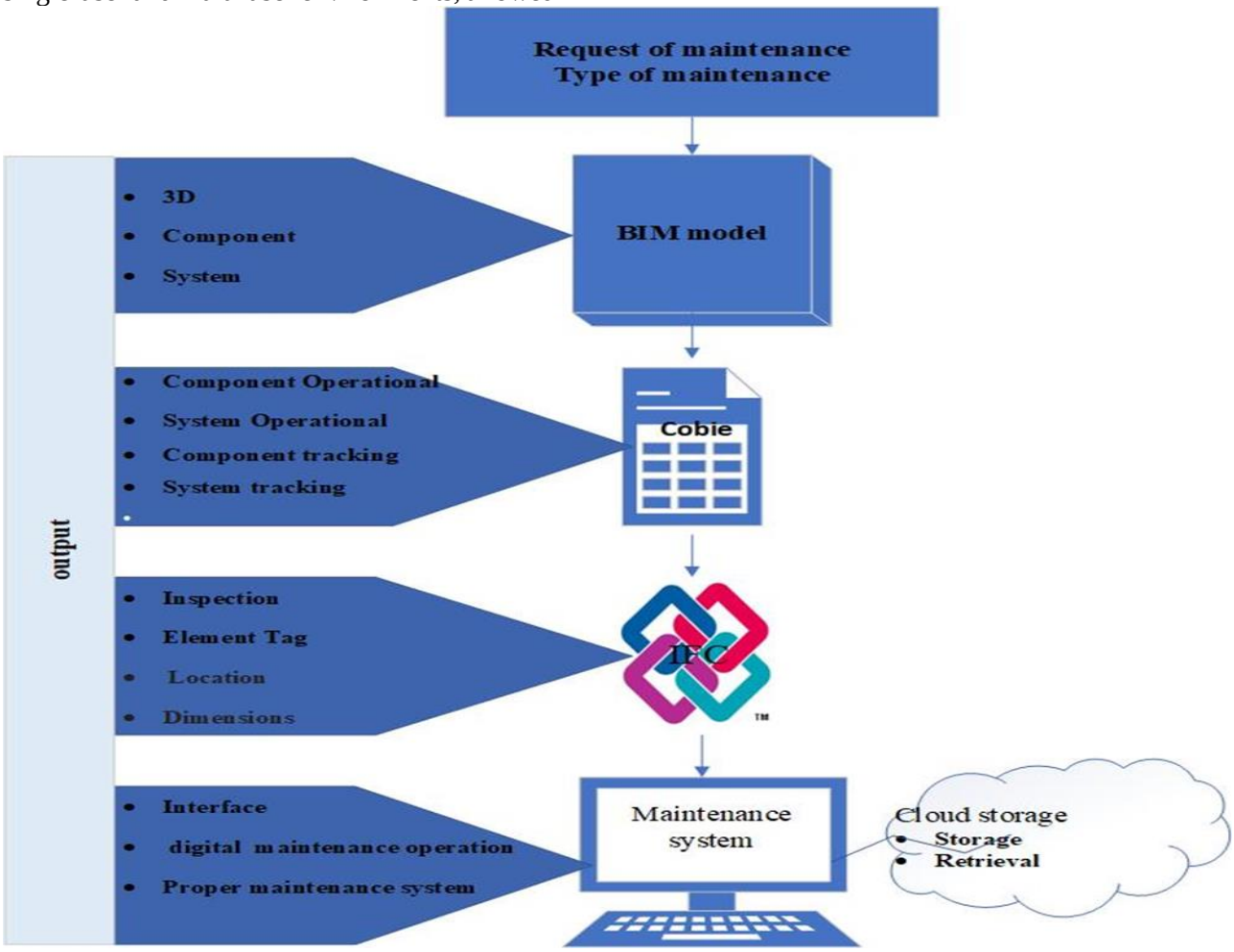

Fig.4. proposed framework for automatic maintenance system.

Conclusion

1. The maintenance system enables maintenance engineers to identify priority, track, coordinate, and manage operating and maintenance activities by providing an effective user-friendly platform.
2. The research findings may be used by organizations, government institutions, and maintenance engineers to develop a better knowledge of the application and execution of maintenance systems in Iraq.
3. The lack of adequate documentation software in Iraq that can be used to cover building maintenance, but using of computer technology and database systems "Cloud storage " improve planning and implementation in maintenance of buildings

4. Effective communication between all project stakeholders during the (design, construction, and maintenance) phases, which improves the effectiveness of building maintenance work and encourages cooperation throughout the building's life cycle
5. Historical data "digital format "for all maintenance orders through view all previous orders that have taken place, and this will reduce corruption in maintenance work

Recommendations

The following things are recommended as suggestions based on the results of this work:

1. Using this strategy, you will be able to rank different maintenance tasks against one another and guarantee that your resources are focused and prioritized to minimize risks.
2. allows users to see and modify information at any time and from any location by application of cloud computing technology in building maintenance
3. handle an emergency maintenance, through designate a separate unit "workshop staff" in each organization or department
4. Communication between the maintenance engineer and the facility manager should be facilitated to minimize interruption and failure to respond to maintenance requests on time.
5. Using maintenance system in early stage of project to reduce errors during design and construction to get more benefit in maintenance stage and achieve acquisition of knowledge between parties

Significance and limitations of the study

The following benefits can be obtained from this research:

1. Providing clarity picture of the digital maintenance system for managing maintenance work especially in Iraq
2. Creating a single system for managing maintenance and aiding decision-making, due to the complexity and high number of maintenance elements for projects, to save effort and time by using it anytime and anywhere
3. Using modern programs and technologies to manage maintenance work rather than the traditional or paper-based way.
4. In the field, mobile access to BIM and other linked/integrated data gives access to all documentation without returning to the office.
5. Integrates BIM, cloud, and Cobie data to provide act analytics, enabling for greater review and access to building controls, schedules, and specifications.
6. To improved technical specifications and requirements based on input from maintenance operations, design and construction teams can produce higher quality building systems.

The study's limitations the case study was that in most Iraqi enterprises, BIM requirements are not applied to the operation and maintenance phase, also school projects in Al-kut city in the Republic of Iraq are spatially limited.

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