Building Maintenance Information System Using 4D Bim Technology for Campus Facilities at Uniciti Alam, Universiti Malaysia Perlis

Muhammad Haziq Bin Harun[1], Zul-Atfi Ismail[1,2,*], Maimunah Sapri[1], Nurul Hana Adi Maimun[1], Hariati Abdullah Hashim[1]

[1]Faculty of Civil Engineering & Technology, Universiti Malaysia Perlis (UniMAP),Arau, Perlis, Malaysia

[2]Centre for Real Estate Studies (CRES), Universiti Teknologi Malaysia (UTM), Skudai, Johor, Malaysia

***Corresponding Author**

DOI: https://doi.org/10.47772/IJRISS.2026.10230010

Received: 08 May 2026; Accepted: 14 May 2026; Published: 28 May 2026

ABSTRACT

Building maintenance encompasses the activities aimed at preserving and restoring a building's and facility's functionality, representing a globally demanding process. Effective maintenance management is crucial for the prolonged use of buildings, ensuring their preservation and promoting health and safety. Traditionally, the paper-based method of managing maintenance, which assigns priorities to each defect, including building amenities, has been associated with various issues such as inadequate maintenance, limited funding, poor services and maintenance backlogs. This study focuses on Block A3 of the Uniciti Alam Campus, University Malaysia Perlis, as a case study to explore best practices in maintenance management. The goal is to propose a new building maintenance information system utilizing Revit and Naviswork Manage software, aiming to enhance the existing maintenance management system. The study also aims to identify and compare issues related to maintenance management between the traditional paper-based method and Building Information Modelling (BIM). The proposed system improvement is intended for implementation in UniMAP's maintenance management system. Research methods employed include literature review and semi-structure interviews to gather relevant data, while Revit and Naviswork Manage software are utilized for research purposes. The anticipated outcome of this research is the improved efficiency of the maintenance management system through the implementation of the BIM method. It is expected to be a beneficial technology aiding staff and owners in addressing maintenance issues, particularly at the Uniciti Alam campus of UniMAP.

Keywords: Building Information Modelling; Building Maintenance; Facility Maintenance; 4D BIM Technology.

INTRODUCTION

Nowadays, the majority of companies in Malaysia continue to utilize traditional methods instead of adopting modern computerized systems for managing building facilities and infrastructure maintenance, including the maintenance management at Uniciti Alam campus, University Malaysia Perlis. Employing these conventional methods results in ineffective and poorly organized maintenance management (Tengku Ahmad & Abd Rasid, 2021). The use of paper-based method also introduces inefficiencies and potential errors in documentation, making it difficult to retrieve and track essential maintenance information. Additionally, the absence of a systematic computational database further exacerbates the organization and accessibility of maintenance records, hindering the ability to effectively plan and prioritize maintenance tasks (Faqih & Zayed, 2021).

Issues such as late of maintenance and maintenance backlog will arise. As a result, the cost of repairing damaged facilities can arise if maintenance is not performed on time. Facility managers will faced with the problem of providing high-quality and fast access to information on facility maintenance, as well as the

demand for more efficient methods of managing information (Yalcinkaya & Singh, 2014). Moreover, this traditional method has an inefficient record-keeping where manual record-keeping is prone to errors, loss and damage. Paper documents can be misplaced, damaged by environmental factors like water or fire, or simply deteriorate over time. Retrieving and organizing information becomes time-consuming and cumbersome. Another issues that can arise is communication and collaboration challenges. This can result in delayed or incorrect maintenance actions, negatively impacting efficiency and effectiveness. Due of that, facility maintenance staff will experiences difficulty in preserving facilities when relying on paper-based document (Aziz et al., 2016).

Most facility maintenance staff using basic Information and Communication Technology (ICT) software such as Computerised Maintenance Management System (CMMS) and Computerised Aided Facility Management (CAFM) to record the information regarding with defects, and maintenance planning as showed in Figure 1. Then, this information will be transformed into paper-based report to be distributed to other personnel that involved in the maintenance management. Besides, there are some maintenance organisation using MS Word and MS Excel completely to support their maintenance task for specific tasks (Espindola et al., 2013). Nevertheless, there is no integration between these systems to improve the communication and collaboration between all parties in the maintenance management especially those involving with the transfer of knowledge in the planning process for buildings (Miettinen and Paavola, 2014).

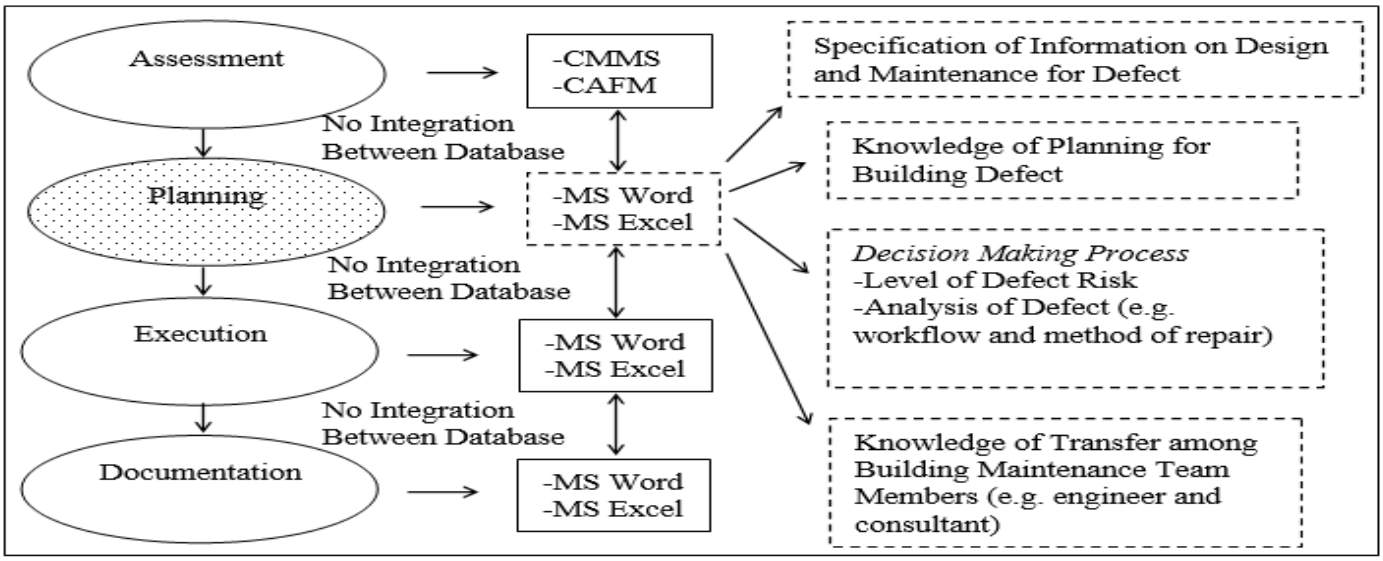


Figure 1: Key Problems for Facility Maintenance Management Practices

Building Information Modelling (BIM) is an enhanced process for planning, designing, building, operating and maintaining facilities. It uses a machine-readable information model that is standardized for each facility, whether it is new or old, and contains all pertinent information gathered or created about that facility in a format that can be used by anyone throughout its lifecycle. BIM has the potential to advance and transform facility Operations and Maintenance (O&M) by providing a platform for facility managers to obtain, analyses and process building in formation in a digitalize 3D environment (Gao & Pishdad-Bozorgi, 2019). Facilities management (FM) is an integrated process used by an organization to maintain and upgrade its physical assets, such as buildings and infrastructure, in order to increase the efficiency of its core operations. In order to preserve and improve building assets and assure the wellbeing of inhabitants, FM involves a wide range of multidisciplinary services. However, most of the process in the existing CMMS and integration of CMMS with Building Information Modelling (BIM) system only focuses on assessment process, rather than more critical process such as planning, execution, and documentation process in dealing with decision making in scheduling (Matarneh et al., 2019).

Table 1 show the research focused on BIM for facility maintenance that is concluded from five (5) current BIM systems that are selected based on major functions in the comparison over current technologies such as knowledge transfer, time simulation and analysis of defect.

Table 1: Research Focused on BIM for Facility Maintenance

Research	BIM System	Planning of Defect		
		Integration of PC Design and Maintenance	Time Simulation	Analysis of Defect
Gnanarednam and Jayasena (2013)	BIM CAFM	Manual and CAFM	No	Record in CAFM
Liu and Issa (2012)	BIM CMMS	Manual and CMMS	No	Record in CMMS
Costin *et al.* (2013)	BIM RFID	Manual and RFID	No	Component Tracking
Chen *et al.* (2013)	BIM Expert	Manual and Expert System	No	Determine the level of component failure for conventional building
Kwon *et al.* (2014)	BIM AR	Manual and AR	No	Visual

In essence, using BIM in FM practice facilitates the management of information concerning a building's components and systems during its lifecycle (Teicholz & International Facility Management Association, 2013). The more accurate and up-to-date the information available to the FM team, the greater the opportunity for the enhancement of processes throughout the O&M phase (Matarneh et al., 2019). (Oluleye et al., 2023), pointed out that BIM can be applied to a facility's lifecycle. BIM capable for creating and maintaining a building facility using an integrated and modern computer model system. Therefore, if properly implemented, BIM could completely change the facility management sector. Maintenance operations, space planning and renovation are some of the benefits that BIM could bring to FM practise. Moreover, (Hoang et al., 2020), claimed that BIM is very important for modelling records, planning maintenance, asset and space during FM activities during the operation stage of facilities. The primary objective of this research centers around applying advanced software, specifically Revit and Naviswork Manage, for the integration of building maintenance information. The chosen subject for this implementation is a six-story university building. The generation of a 3D model for the building was achieved by utilizing the existing drawings, employing the student versions of Autodesk Revit and Naviswork Manage.

LITERATURE REVIEW

Facilities maintenance management is a main topic for this research where its involves a wide range of multidisciplinary services with an overall purpose to maintain and enhance building assets to ensure occupants' wellbeing (Matarneh et al., 2019). Effective facility management is essential for creating a safe, functional and productive environment for occupants while ensuring the efficient and sustainable operation of a facility. Facilities managers often work closely with other stakeholders, such as building owners, tenants, maintenance teams and service providers, to ensure that the built environment is safe, efficient and cost-effective. Next is adoption of Building Information Modelling (BIM) where it's a digital representation and management system for building projects. It entails generating a virtual model that incorporates geometry, spatial relationships, numbers, material specifications and other pertinent information about the construction or maintenance management especially on facility maintenance management. Throughout the course of a project, BIM offers a collaborative environment that enables collaboration between architects, engineers, contractors, and other stakeholders. BIM also is a three-dimensional (3D) model that contains all the information of engineering projects from the design stage to construction and operation, providing functions of visualization, informatization and integration (Li et al., 2023).

Building information modelling (BIM) also a novel strategy for designing and documenting construction projects. The building team is better able to make decisions thanks to the information that BIM models and manages, which includes information that enables the automatic generation of drawings and reports, design analysis, schedule simulation, facilities management and more. A comparison of various design options can be made using the analysis to determine how a building will perform under specific conditions (Shaikh et al.,

2020). The adoption of BIM has grown more widespread in the architecture, engineering, and construction (AEC) sector as a result of its capacity to enhance maintenance management, project visualization, boost collaboration, decrease errors and rework and enable data-driven decision-making. BIM has the ability to boost productivity, minimize costs and improve the overall quality of building projects throughout their lifecycle. BIM also offers a single source of truth wherein all project-related information is stored, processed, and managed in a central hub (Chen et al., 2023). The Public Works Ministry in Malaysia is currently focused on enhancing the utilization of the Building Information Modelling (BIM) within the country's construction industry. The aim is to maximize the adoption and implementation of these advanced systems in order to improve efficiency and effectiveness in the construction sector. According to (Bernama, 2023), minister Datuk Seri Alexander Nanta Linggi stated that the integration of Building Information Modelling (BIM) is a highly influential strategy that has the potential to decrease reliance on foreign workers in the construction sector by enhancing competencies and adopting technological advancements. This indicates that BIM is a particularly suitable solution for implementation in today's construction industry.

According to (Hamil, 2021), the BIM can be defined with a few types of dimensions which are 1D BIM, displaying process and management while 2D BIM focusing on modelling. Following, 3D BIM is more to three-dimensional geometry and information graphics modelling. Moreover, 4D BIM is a linked to data that time-related while 5D BIM focuses on cost analysis, such as monitoring, control and planning cost. For 6D and 7D BIM are discusses about sustainability, as well as building management, maintenance issues and life cycle of project. Next, 8D BIM, it deals and focus with safety during design and construction and for 9D BIM focus on lean in construction. Lastly, 10D BIM is focus on industrialization construction. For this research, a 4D BIM is focused on where the dimensions that require to adding scheduling information into model construction sequences. The project team can more clearly envision how the construction will be done by including a time dimension. This is essential from the perspective of a contractor. When 4D BIM was first made possible by the use of new modelling tools, it represented a significant advancement for the industry. The ability to better understand the construction plan through 4D visualizations is one of 4D BIM's accomplishments. According to (Gong et al., 2019), 4D visualizations can be defined as simpler representations of the development of the project and can be used by a wider variety of project participants at varying levels of skills and experience.

Issues Of Building Maintenance

In Malaysia, one of the most significant issues on the national agenda is building maintenance (Hauashdh et al., 2020). It is due to the lack of regular maintenance for buildings during their occupancy, and this negligence can be a contributing factor to major accidents. The consequences of deferred maintenance are multifaceted, ranging from structural deterioration and compromised safety to increased repair costs over time. Buildings that do not undergo regular upkeep face a heightened risk of structural failures, electrical malfunctions, plumbing issues and other potential hazards that may jeopardize the well-being of occupants and the surrounding community.

Furthermore, the impact of inadequate building maintenance extends beyond safety concerns. It can result in a decline in the aesthetic and functional aspects of structures, reducing their overall value and potentially affecting property values in the surrounding areas. The economic ramifications of such neglect are substantial, as emergency repairs and structural rehabilitation often incur higher costs than routine maintenance.

Thus, many buildings in Malaysia lack comprehensive records detailing their construction details, past maintenance activities, and modifications. This deficiency hampers the ability of maintenance teams to make informed decisions and plan for future upkeep effectively. (Faqih & Zayed, 2021). Some buildings in Malaysia also may still rely on outdated systems and technologies that are difficult to maintain due to a lack of spare parts or qualified technicians. Upgrading these systems becomes challenging without proper documentation and understanding of the existing infrastructure. To address these challenges, Malaysia must adopt a multifaceted approach that encompasses technological audits, capacity building, incentives for upgrades, public-private partnerships, and the integration of smart building solutions. By doing so, the nation can bridge the gap between legacy systems and modern technologies, fostering a built environment that is not only resilient and safe but also equipped to meet the demands of the future.

METHODOLOGY

A. Research Instrumentation

Research instrumentation serves as a tool to gather, measure and analyze data pertinent to the study's focus. Therefore, this study aims to explore maintenance management issues by comparing the traditional (Paper-based) method with the Building Information Modelling method, utilizing semi-structured interviews. A semi-structured interview is a type of interview that incorporates aspects of both organized and unstructured interviews. Semi-structured interviews are thought to have greater promise than other interview formats because they enable researchers to get comprehensive data and supporting information from interview subjects while thoughtfully pondering the study's main objective (Ruslin et al., 2022). According to Kapoor and Saigal (2013), semi-structured interview is based on the phenomenological paradigm, which uses a variety of interpretive methodologies. Interview also uses systematic procedures to conduct in-depth study of research question. Interview technique is the reflective and process driven, where the aim is to produce culturally situated and theory-enmeshed knowledge through an ongoing interplay between theory and methods, researcher and researched. This approach produces both exploratory and highly descriptive knowledge while deemphasizing the solely cause models and explanations that have historically dominated the research process (Hesse-Biber and Leavy, 2011). The semi-structured interview was undertaken to explore the precise topic and to inquire specific open-ended questions regarding the problems in maintenance management, approaches to addressing problems, ICT implementation, use of emerging technologies and maintenance management system. The semi-structured interviews were conducted with one facility manager (Respondent 1 (R1)), one engineer(R2), one assistant engineer (R3) and one technician (R4)) who were responsible for the maintenance management of the entire building structure under the Facility Management and Development Unit (UPPF) of UniMAP Holding Sdn. Bhd. The interview sessions took around five hours to accumulate the data on the maintenance processes including the demonstration of the current maintenance management system with the implementation of the ICT tools by the engineer. All the data from the interviews were recorded using video camera and transcribed verbatim. The semi-structured interview will be carried out face-to-face to enhance comprehension of a given situation or perspective from the respondent's point of view, thus prompting adjustments to questions and sequencing to align with the study's focus. The insights and noteworthy discoveries obtained during the interview session will be meticulously recorded for documentation.

Through this case study, the manual process of maintenance management can be established to gain in-depth understanding for clarifying the desirable system under maintenance management staff required at UniMAP. For the purpose of this case study, a component of qualitative content analysis can be described. The component has been separated into the unit of analysis to vary across specific research situations. The unit of analysis is the entity on which there are data and which will be subjected to statistical analysis (Tainton, 1990). The unit of analysis for this study was based on the “embedded units of analysis” adopted were as follows:

a. Maintenance Management Problems: To investigate the major problems on the maintenance management practices;

b. Approaches to address problems: To identify the strategy that are used by engineer in reducing the problems that involved in maintenance operation;

c. ICT implementation: To identify the current technology of ICT practices to improve the particular maintenance processes;

d. Use of emerging technologies: To investigate the potential of the emerging technologies to facilitate maintenance management practices; and

e. Maintenance Management Systems: To identify the maintenance procedures.

The justifications for the selected case study was according to the following main criteria: exposed to the traditional method used and major problems, attempted to implement computerised technology and the willingness of staff to share their experiences in improving the maintenance management processes at

UniMAP. This study also aims to develop a new building maintenance information system that will use 4D BIM technology where implement Revit and Naviswork Manage software to enhance the current maintenance management system. To achieve these aims, the instrument that used is by recreate 3D model of Uniciti Alam building using Revit software first. Building details are very important to recreate the model of Block A3 Uniciti Alam. The building details which is architecture plan was obtained from the Facility Manager of UniMAP Holding Sdn. Bhd. Next is defect complain for facilities such as lockers, beds and study desks of Block A3 Uniciti Alam were obtained from the Facility Management department from UniMAP Holding, Sdn. Bhd to develop the maintenance schedule. Then, Navisworks Manage software is used to support the Revit software to enable the 4D simulation of maintenance processes. The schedule is meticulously crafted and the timeline simulation is automatically produced based on the selected components, namely bed, locker, and study desk. The Time-Liner tables within the schedule showcase planned start and end dates, along with the actual dates when maintenance activities are initiated and concluded.

B. Research Flowchart

The flowchart outlined in four steps, as illustrated in Figure 2, begins with the initial phase of establishing objectives based on existing problem statements. Following this, a review of literature related to the identified issue is conducted. In the second stage, research methodologies are applied, involving semi-structured interviews and the compilation of a data list detailing damages to campus facilities like lockers, study desks, and beds. A semi-structured interview is conducted with representatives from the Facilities Management department at UniMAP Holding Sdn. Bhd. to gather insights from their perspective. Moreover, a 3D model of Block A3 Uniciti Alam at University Malaysia Perlis is created using Revit software. The complaints data related to campus facilities are then digitized into a maintenance schedule using Revit software and linked to Naviswork Manage software to create timeline simulation. The final stage, Stage 4, involves the discussion, conclusion and recommendations.

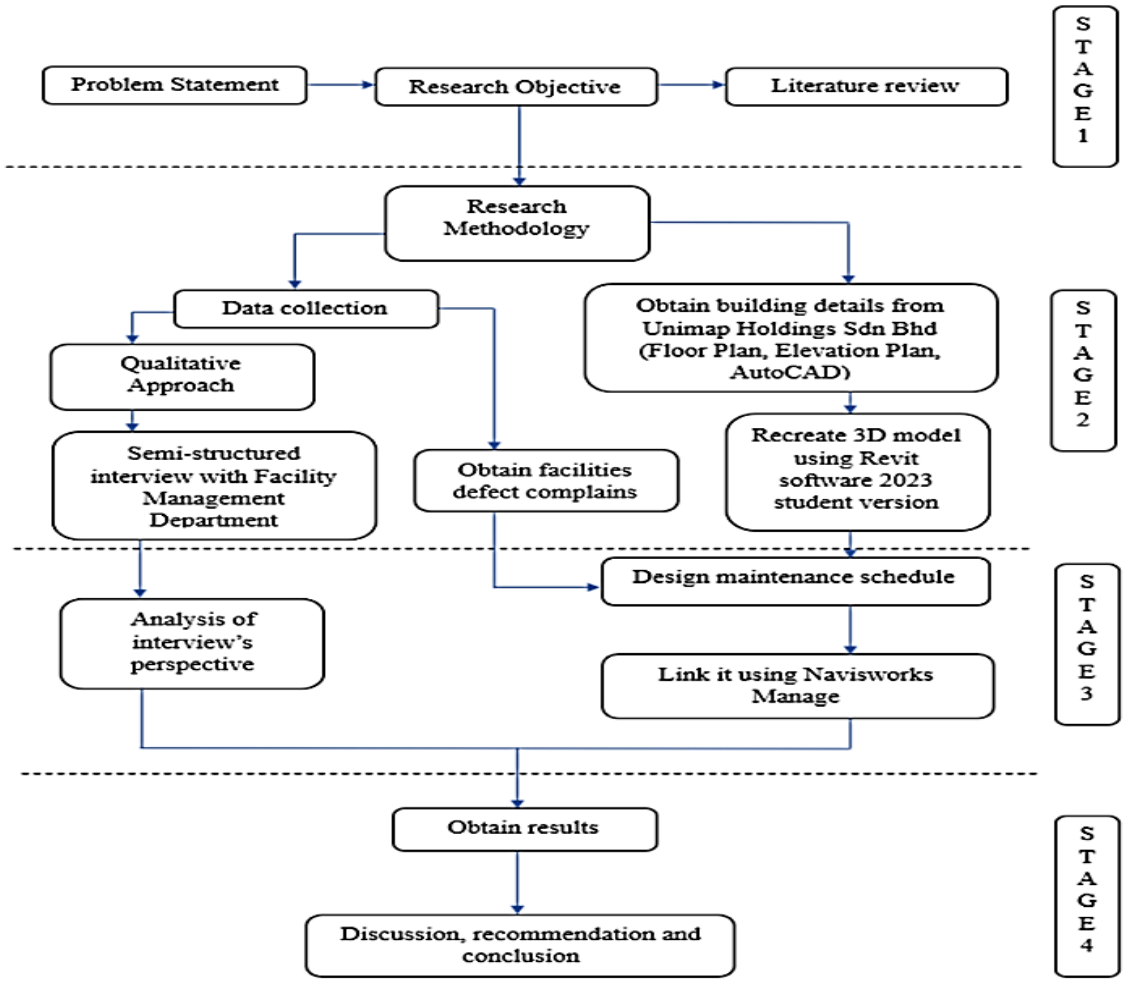


Figure 2: Flowchart of research methodology

C. Building Details

Building details are very important to recreate the model of Block A3 Uniciti Alam. The building details which is architecture plan was obtained from the Facility Manager of UniMAP Holding Sdn. Bhd. To propose building maintenance information system using Revit software, building details included floor plan, roof plan, elevation view, front view, right view and cut section were needed for recreated 3D model of Block A3 Uniciti Alam, University Malaysia Perlis.

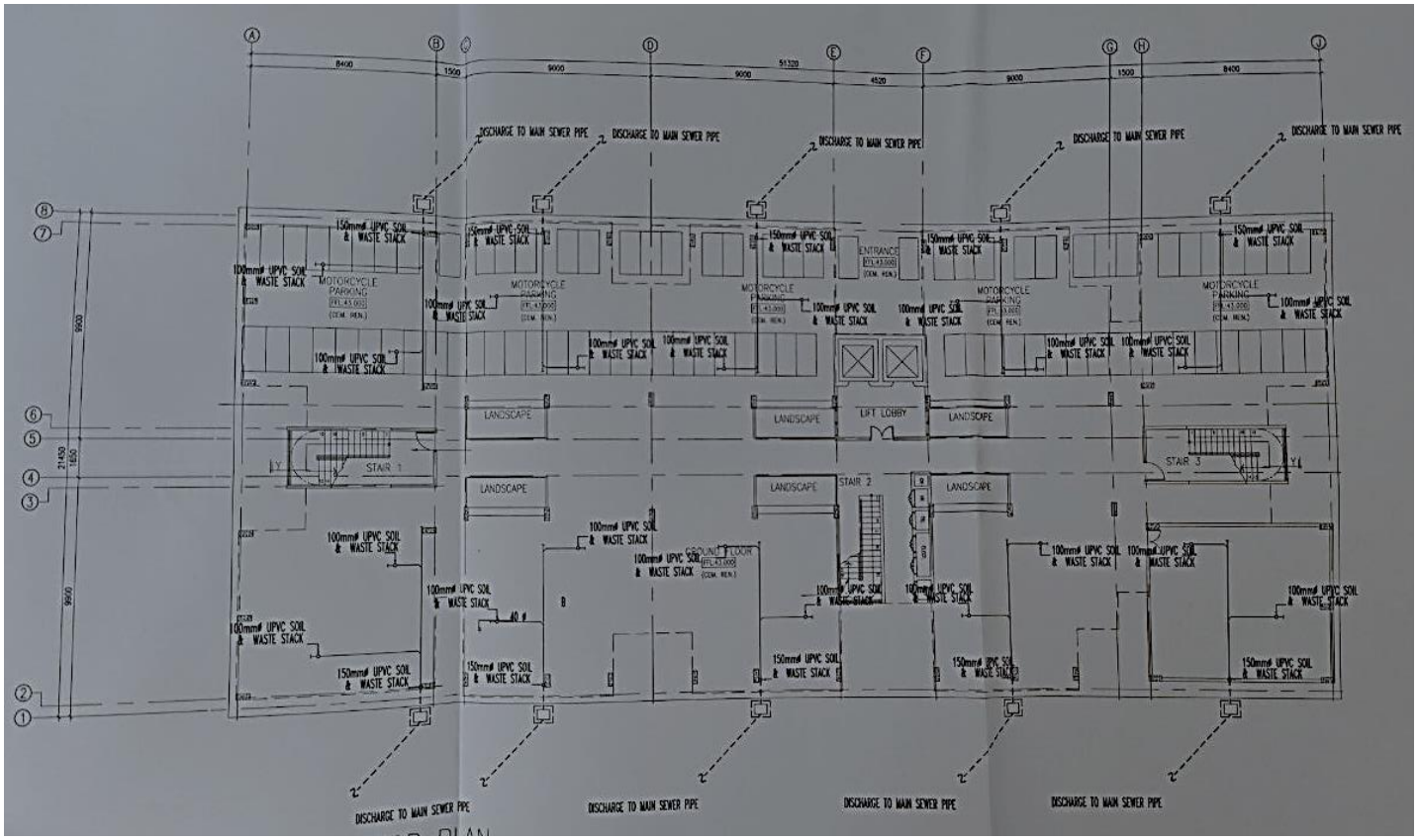


Figure 3: Ground floor plan of Block A3 Uniciti building obtained from Unimap Holding

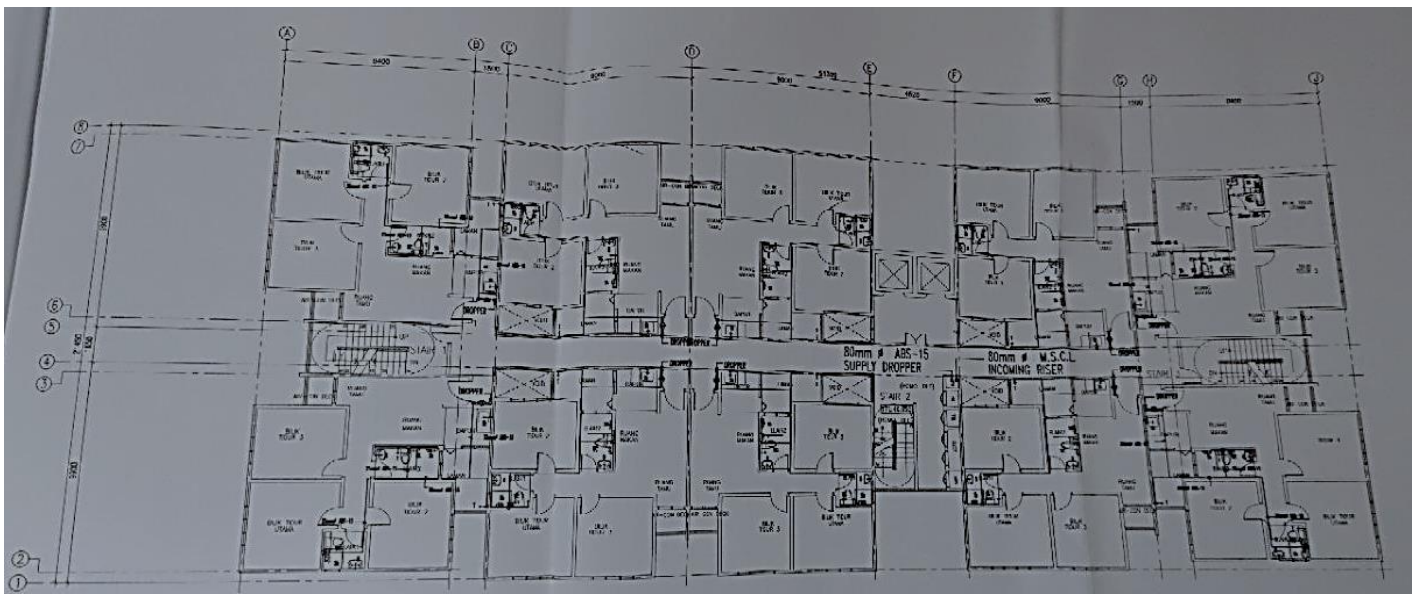


Figure 4: First to six floor plan of Block A3 Uniciti building obtained from Unimap Holding

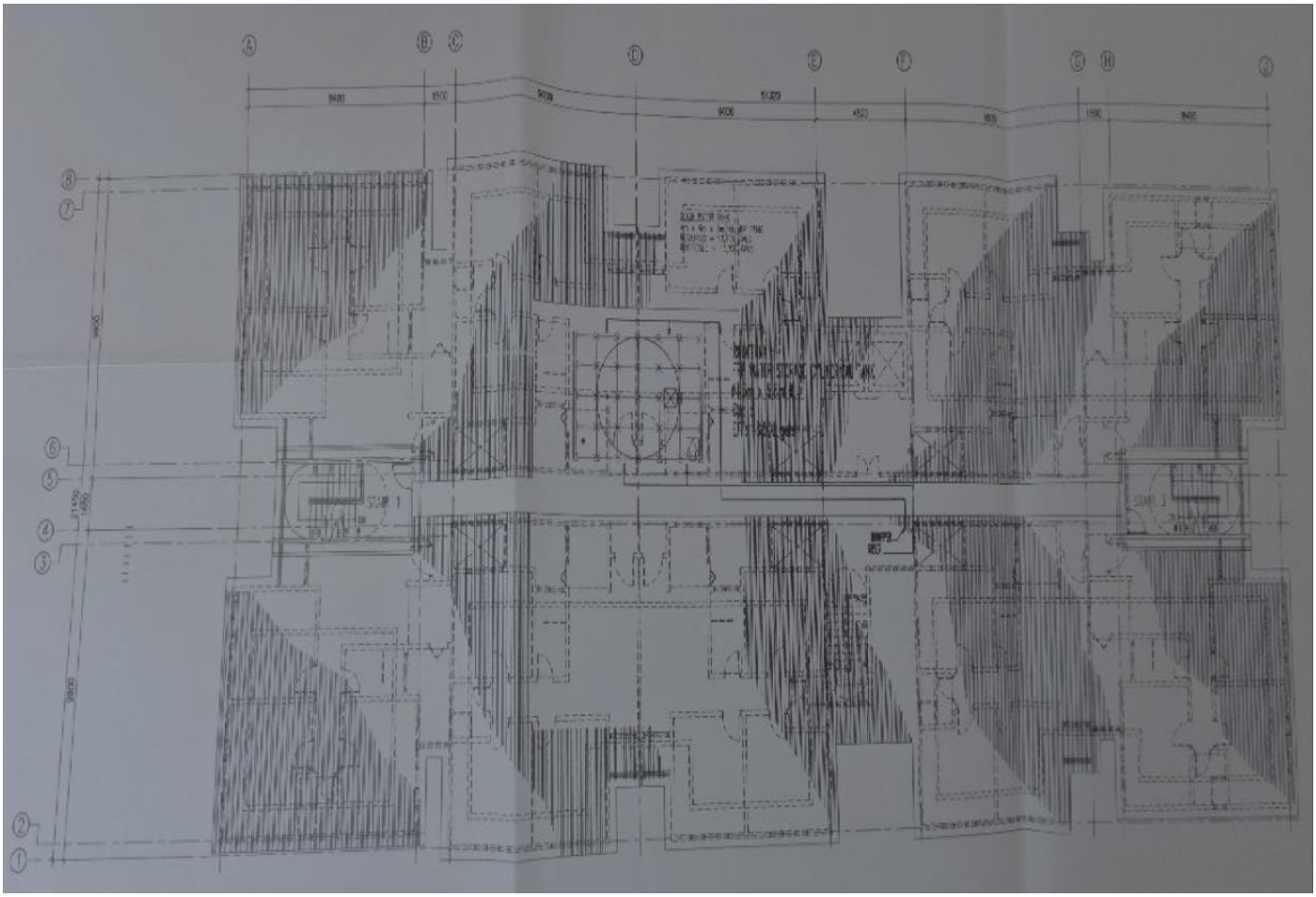


Figure 5: Roof floor plan of Block A3 Uniciti building obtained from Unimap Holding

RESULT AND DISCUSSION

A. Analysis of Interviews

The primary research objective was fulfilled through interview sessions involving four respondents, elucidating nine distinct question categories. Utilizing the information gathered from the respondents, the cross-case analysis is applied to comprehensively examine the responses from those participants.

Table 2: Cross-case analysis based on interviews

Respondent	Element of Analysis
R1-R4	Facility Maintenance Management System
	- Conventional Method (Example: paper-based reports and unsystematic databases)
	Implementation of ICT
	- Conventional Method (Example: Microsoft Word and Microsoft Excell) mySPATA- Data inventory for immobile facilities (e.g. building) mySPA- Data inventory for mobile facilities (e.g. furniture) E-Aduan System- for managing complaints
	Facility Maintenance Management Problems
	- Cost Management • Delayed complaint delivery • Limited budgets

	- Communication obstacles • Lack of motivation for reporting defect • Undelivered complaint • Nonspecific complaint - Risk of data loss • Defects repetition • Time gap of building repairs • Poor quality contractor
	Use of Emerging Technologies - There is no use of any emerging technology for facility maintenance management
	Approach to Problem Solving
	- Adoption of BIM method on facility maintenance management • Provide more frequent inspection and assessment in identifying the causes of defect • Training courses for technicians • Improve the maintenance assessment for the building works did by main contractor
	Duration of Facility Maintenance Process
	- No specific timeframe for handling facility damages
	Recommendation Method on Performing Facility Maintenance Management
	- BIM method system - CMMS method system

Scope of Study: Block A3 Uniciti Alam, UniMAP

The building chosen for this study is a campus building located in Padang Besar, Perlis. The maintenance improvements focused in this study are related to facility maintenance. The R1 is responsible for managing the coordination operations to ensure the sustainability of the building facilities.

Maintenance management system

Maintenance management at this building is currently being operated through a conventional system that relies on paper-based reports and unsystematic databases, managed by the maintenance staff.

Implementation of ICT

This maintenance approach, relying on basic ICT systems such as Microsoft Word and Microsoft Excel spreadsheets, represents a rudimentary method for managing and documenting complaint defects as well as recording overall maintenance progress information.

Maintenance Management Problems

There are several problems identified in this building:

Cost Management: All respondents agreed that the primary difficulty in facility maintenance management is cost management. The ongoing challenge revolves around managing maintenance expenditures while maintaining the reliability of equipment.

Communication obstacles: The paper-based approach may encounter challenges related to communication due to physical documents, making it harder to ensure real-time updates and collaboration, similar to the first responder's statement.

Risk of data loss: As the R3 mentioned, the risk of data loss is higher in a paper-based system due to physical vulnerabilities, such as misplacement, damage or destruction.

Use of Emerging Technologies

This building is not supported by emerging technologies such as BIM (Building Information Modeling) and CMMS (Computerized Maintenance Management System), hindering its ability to optimize design, construction, and maintenance processes.

Approach to Problem Solving

In addressing issues arising from the paper-based approach in facility maintenance management, the adoption of BIM methods, particularly leveraging BIM 4D technology utilizing Revit and Naviswork Manage software, proves effective in the management of facility maintenance. This advanced approach not only helps overcome the challenges associated with the paper-based system but also enhances the efficiency and precision of facility maintenance management at Uniciti Alam building.

Duration of Facility Maintenance Process

The time taken to address facility damages at Uniciti Alam building, following a defect complaint can fluctuate considerably due to various factors. Factors influencing the duration include the type and seriousness of the damage, the availability of resources, the complexity of the task, and established organizational procedures.

Recommendation Method on Performing Facility Maintenance Management

BIM method system: The R2 indicates a preference for incorporating BIM for facility maintenance management at Unciti Alam building. Although advises integrating the BIM system with CMMS.

CMMS method system: R3 suggests employing a CMMS as the appropriate system or method for executing maintenance management at Uniciti Alam building.

Issues Related to Facility Maintenance Management

There were many problems related to the traditional method in maintenance management at UniMAP such as defect repetition (leaking and cracking) and less competent contractor. The traditional method also led to inaccurate design and construction information, late updating of the required information, lack of coordination and integration. Therefore, the transformation of the traditional process into the computer-based systems is important to improve the maintenance management processes for complex services, in the works of planning and to reduce the defects for structural component. In the case study, the R1 revealed that a number of shortcomings in the traditional method. The building defect knowledge was insufficient to facilitate the maintenance management staff to handle the data loss and solve the defects. The information record was also inaccurate in order to assess the condition of component and other decision making information. The maintenance planning and execution was not able to address the building structure defect problems at the particular location due to the less communication between all members in maintenance management. Furthermore, the less competent contractor caused the maintenance faults to be increased to encourage the deterioration of the building structure and facility. In this research, the frontline approaches (new BIM system development with the integration of Naviswork) is intended to address the maintenance management problems on UniMAP building which are:

i. Defect repetition information and knowledge due to failure to communicate the actual level of structure defect;

ii. Defect repetition (leaking, jointing and cracking) information and knowledge due to data loss; and

iii. Less competent contractor due to lack of knowledge regarding with materials, method and plan of structure repair.

Therefore, it can be identified that are few issues arise that related to facility maintenance management between a traditional method which is paper-based and the Building Information Modelling method which are Revit software with Naviswork Manage software.

Table 3: Issues that arise from both system of maintenance management

Traditional method	BIM method
Communication obstacles	Complexity
Risk of data loss	Training requirements

The identified issues in facility maintenance management encompass communication obstacles as a primary concern with the paper-based approach, where challenges arise due to the reliance on physical documents, making real-time updates and collaboration more difficult. Additionally, the risk of data loss is heightened in a paper-based system, given its susceptibility to physical vulnerabilities like misplacement, damage or destruction. On the other hand, the Building Information Modelling (BIM) method introduces its set of challenges. Notably, it brings about complexity, especially concerning software usage and the associated learning curve for staff unfamiliar with the technology. Moreover, the BIM method entails training requirements for users to proficiently navigate and utilize Revit software and Naviswork Manage software, potentially necessitating an initial investment in training programs. Based on the analysis, it indicates that both the traditional paper-based method and the Building Information Modelling (BIM) method have their unique challenges in facility maintenance management.

Autodesk Revit

The development of Block A3 Uniciti Alam's 3D model involves the utilization of Autodesk Revit software, renowned in the field of building information modelling (BIM) for its versatile functionality and comprehensive application of the BIM concept. This software is widely adopted due to its capability to support various databases necessary for system development and facilitate remote access to BIM data. This process involves translating the information from AutoCAD 2D (two-dimensional) plans into a 3D (three-dimensional) representation, with Revit's extensive tools for graphical data processing playing a crucial role in this transformation.

3D Model of Building

To propose Building Maintenance Information system for Uniciti building, the 3D model of block A3 of Uniciti building was created before proceed to next method. This preliminary step lays the foundation for the implementation of the proposed system and ensures a comprehensive understanding of the building's structure and layout.

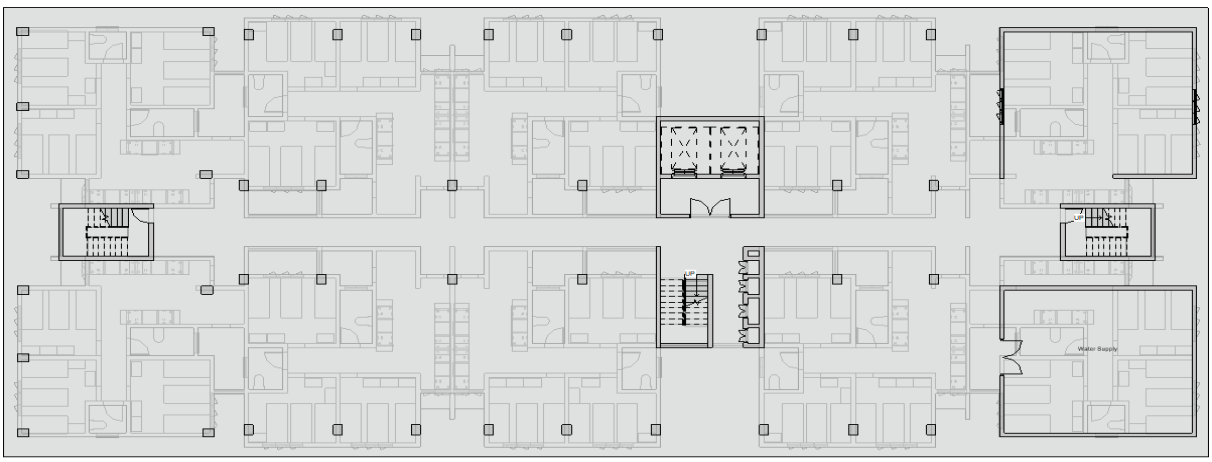


Figure 6: Ground floor plan of Block A3 Uniciti building

Figure 7: Floor plan from level 1 to 6 including facilities component such as lockers, beds and study desk at Block A3 Uniciti building

Figure 8: Roof floor plan of Block A3 Uniciti building

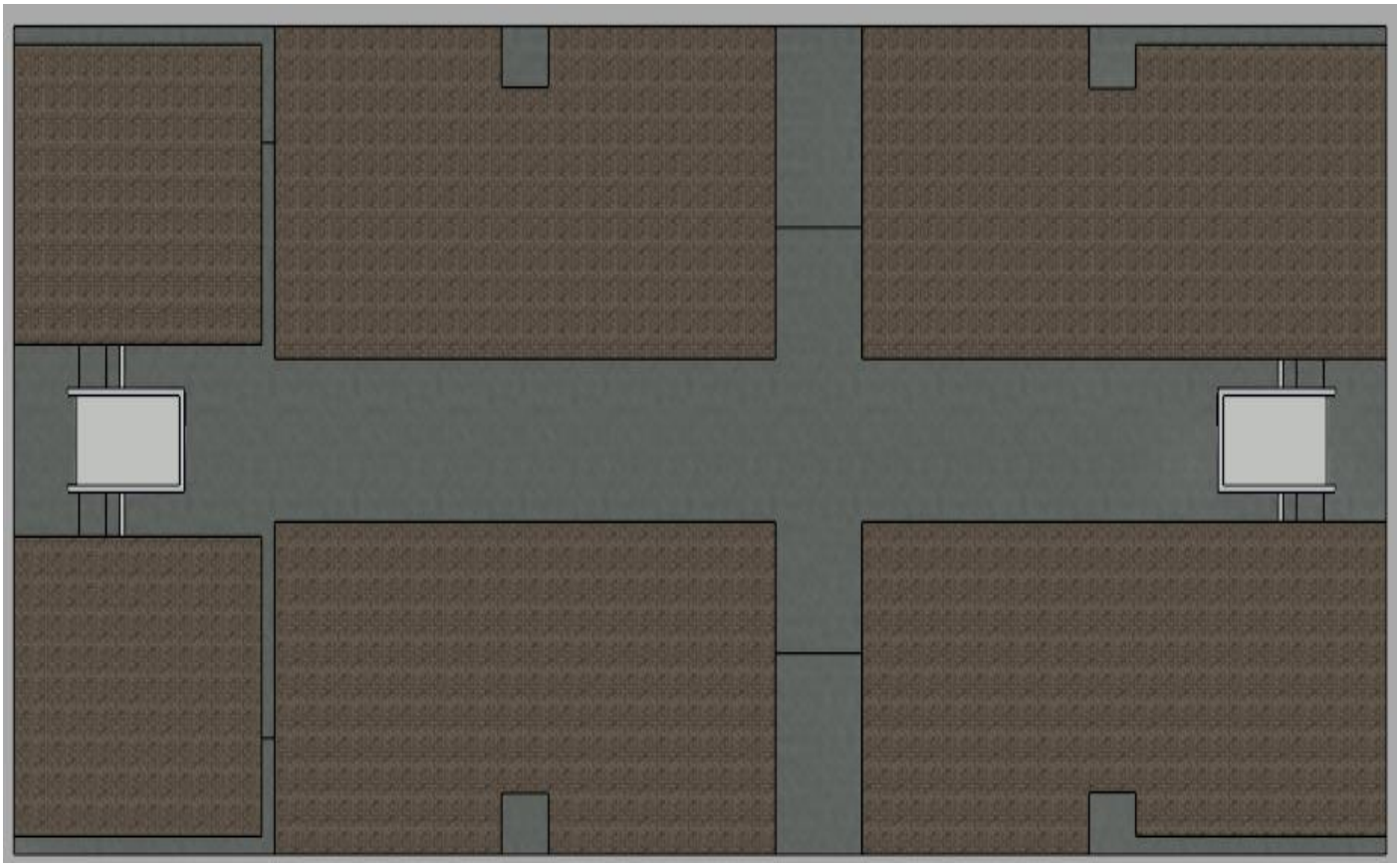
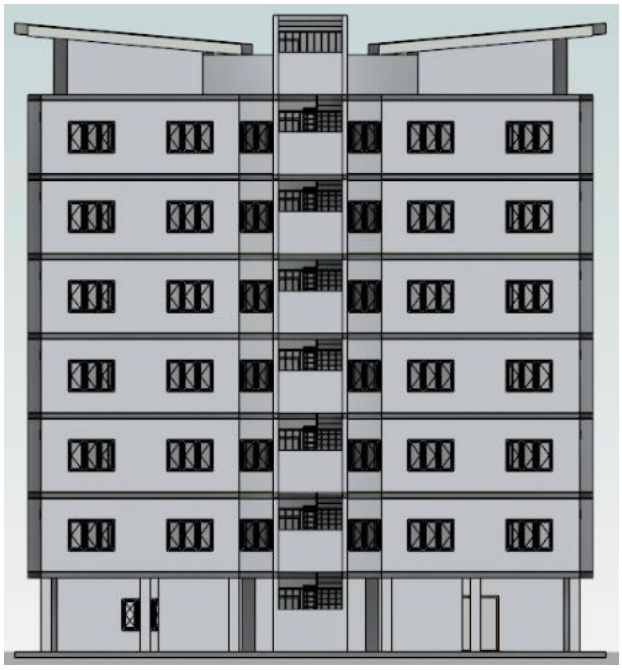


Figure 9: Roof plan of Block A3 Uniciti building

Figure 10: Front elevation of Block A3 Uniciti building

Figure 11: Rear elevation of Block A3 Uniciti building



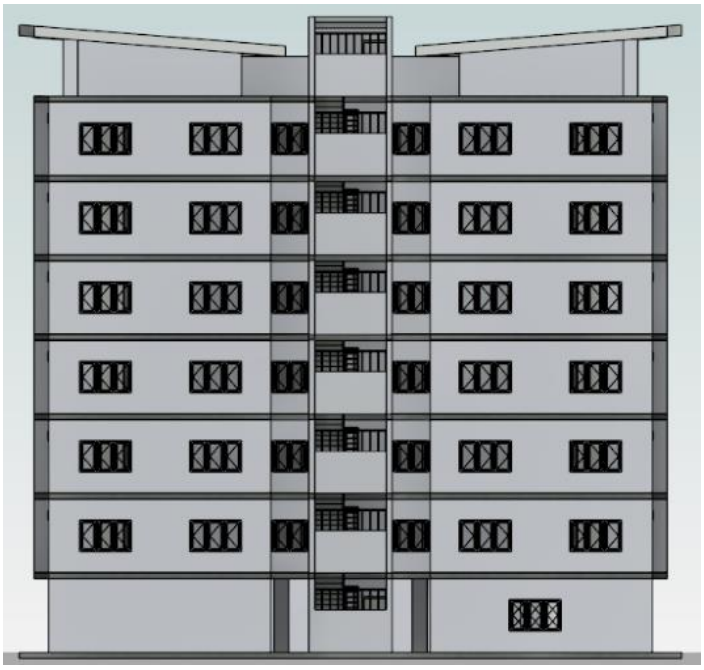


Figure 12 and Figure 13: Right and left elevation of Block A3 Uniciti building

Figure 14: 3D view of Block A3 Uniciti building

Defect Complaint

The data collected from the Facility Management Department of Unimap Holding Sdn. Bhd. comprises defect complaints, forming the basis for this research's emphasis on three specific elements: beds, lockers, and study desks. The primary objective of gathering this data is to identify and categorize the types of defects associated with these three elements. This detailed defect analysis serves as crucial input for the subsequent creation of a maintenance schedule within Revit software. By leveraging the capabilities of Revit, the aim is to systematically plan and schedule maintenance activities to address the identified defects efficiently.

Table 4: Report damage of facilities at block A3 Uniciti Alam

DEFECT COMPLAINT REPORT (Universiti Malaysia Perlis)						
No.	**Date**	**Reference No.**	**Complainant's Name**	**Details Complaint**	**Priority**	**Status**
1	20/1/2021	WRUNIMA P2100954	Nurul Hafiza binti Mokthar	Rusty on the door side of locker.	Normal	Completed
2	5/3/2021	WRUNIMA P2101125	Muhammad Adib bin Rosli	Damaged door of locker's hinges.	Normal	Completed
3	15/7/2021	WRUNIMA P2101356	Siti Aisya binti Hassan	Weak joints and connections of study desk.	Normal	Completed
4	28/2/2022	WRUNIMA P2200235	Pan Kong Yew	Scratches and dents on the desk surface.	Normal	Completed
5	8/5/2022	WRUNIMA P2201432	Hadli bin Mohd Mizuan	Squeaking or creaking noises on the bed.	Normal	Completed
6	9/8/2022	WRUNIMA P2201565	Muhammad Adib bin Rosli	Uneven and wobbly legs of study desk.	Normal	Completed

7	14/11/2022	WRUNIMA P2202345	Muhammad Amzar bin Rashid	A noticeable sagging in the center of the mattress.	Normal	Completed
8	12/4/2023	WRUNIMA P2300675	Shasmitha a/p Anathan	Broken lock mechanism of locker.	Normal	Completed
9	20/6/2023	WRUNIMA P2301243	Choo Jah yee	Broken bed frame.	Normal	Completed

Maintenance Schedule

Maintenance schedule is generate then using Revit software after completed the architectural 3D model. The types of defects incorporated into the maintenance schedule are derived from the defect complaint data previously obtained. Based on the model that have been created, all data including the type and details of defect and also the status of the defect can be directly keyed-in and modified into the predefined categories from project parameters. Subsequently, this keyed-in of data can be presented in the maintenance schedule. In addition, by aligning the maintenance schedule with the actual reported defects, the Revit software enables a targeted and efficient approach to building maintenance, facilitating timely resolution of identified issues of defects. Furthermore, the use of Revit software enhances collaboration among stakeholders involved in building maintenance. The shared platform allows for real-time updates, fostering effective communication and coordination among team members.

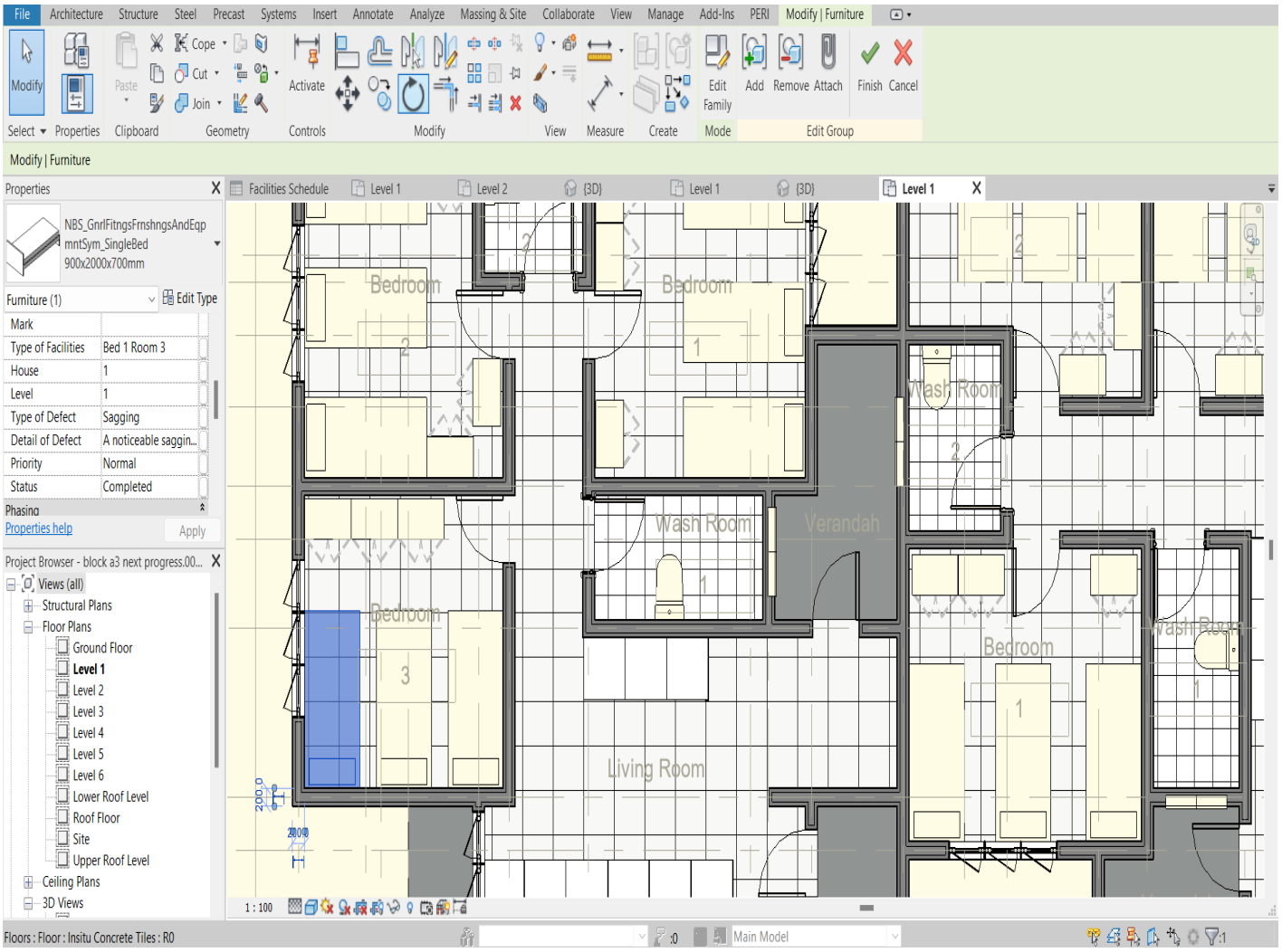


Figure 15: A data of defects that keyed-in into identity data

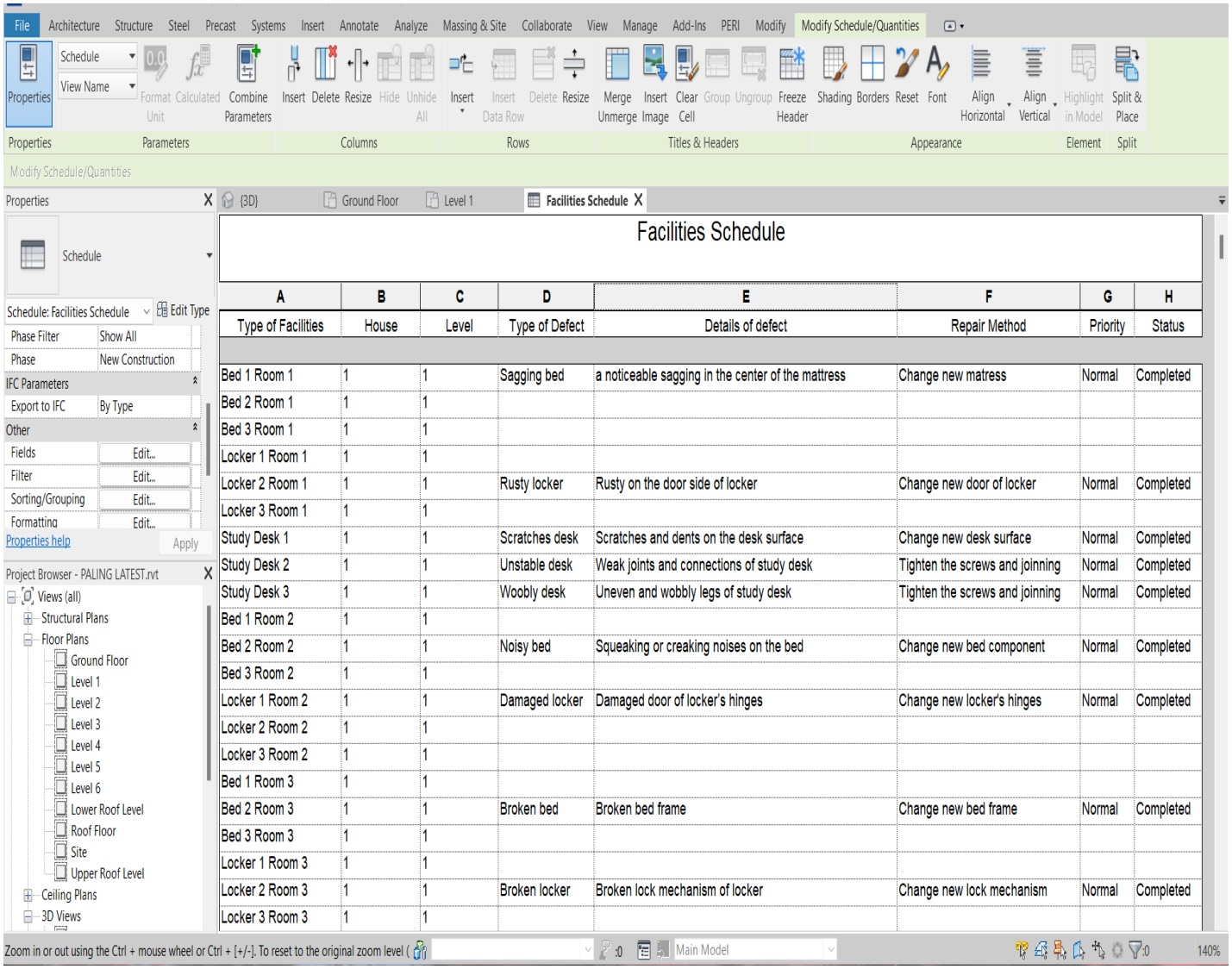


Figure 16: A maintenance schedule based on defect complain at level 1 of building

Autodesk Naviswork Manage

In order to accomplish the objective of the study, Navisworks Manage software is used to support the Revit software to enable the 4D (four-dimensional) simulation of maintenance processes. The completed Revit model will export into IFC files format, then will be transferred into Naviswork Manage software to create the Time-liner table. The 4D simulation facilitated by Navisworks Manage enhances project maintenance understanding, enabling better communication among team members and stakeholders. Navisworks Manage software offers the capability to conduct timeline simulations, which entail the creation of construction schedules and the simulation of construction sequences (Firdaus Razali et al., 2019).

Timeline Simulation

Generate timeline simulation using Naviswork Manage software that are focuses on type of component facilities which are selected such as lockers, beds and study desks. All the facilities component can be transferred to Time-liner table to create timeline simulation for visualize and analyze the scheduled maintenance activities. This simulation serves as a dynamic representation of the maintenance timeline, allowing stakeholders to gain a comprehensive understanding of when specific maintenance tasks are planned and how they interrelate. This visual tool provides valuable insights into the temporal aspects of maintenance activities, promoting efficient resource allocation and aiding in the identification of potential scheduling conflicts.

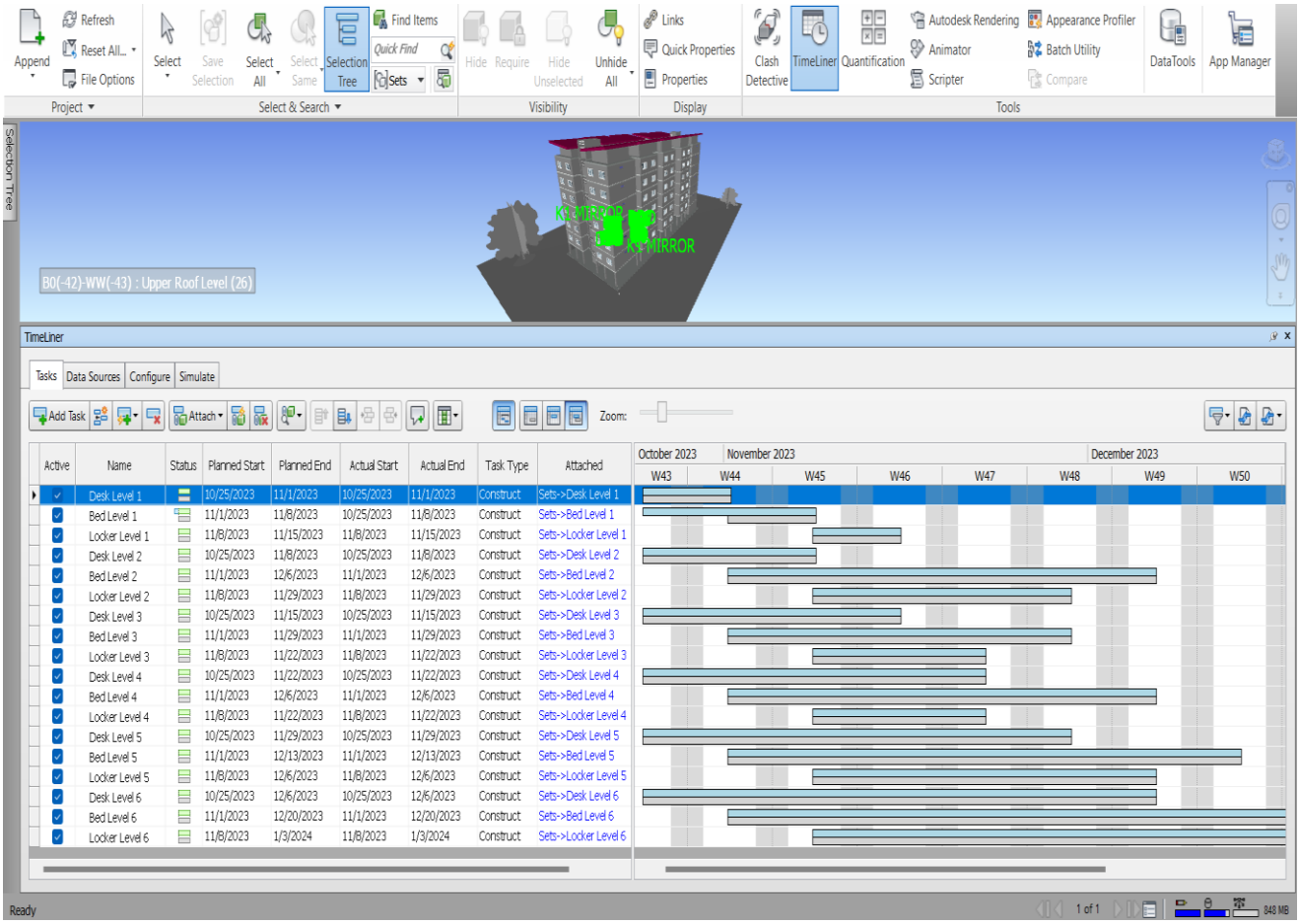


Figure 17: A Time-Liner tables to generate the timeline simulation

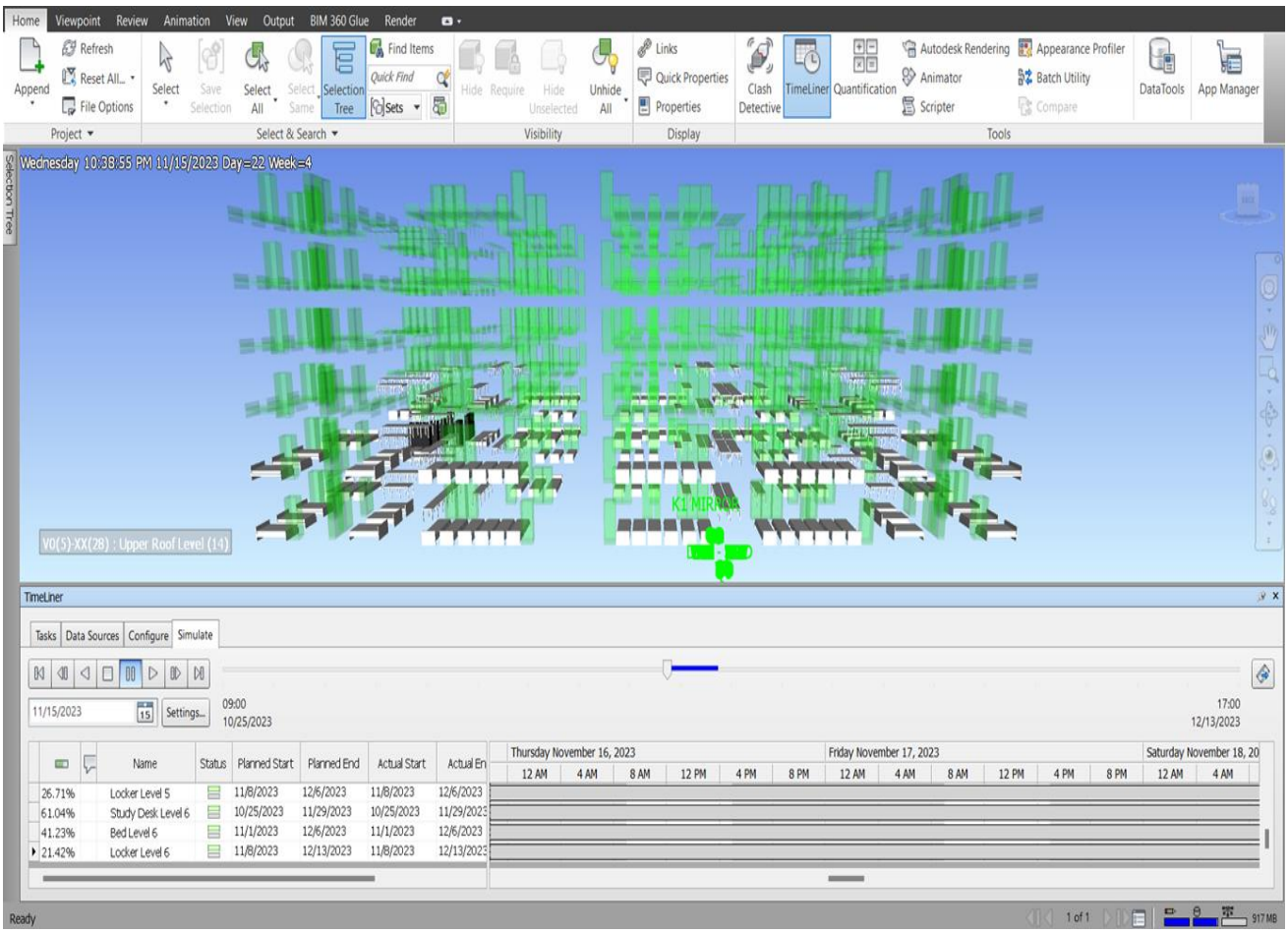


Figure 18: Timeline simulation for facilities of block A3 Uniciti building

Implication

Based on analysis, it can be concluded that there is some implication when adopt the Building Information Modelling (BIM) method, employing Revit software and Naviswork Manage software, in facility maintenance management compared to the traditional paper-based method. First implication is communication efficiency. The BIM method excels by offering improved communication through digital collaboration tools, enabling real-time updates and effective collaboration among stakeholders. In contrast, the paper-based method may experience delays and inefficiencies in communication due to its reliance on physical documents.

Next implication is data security and integrity, where the BIM method provides a more secure environment for data through digital storage and backup capabilities, mitigating the risk of data loss associated with physical vulnerabilities. On the other hand, the paper-based method is susceptible to the risk of data loss due to issues like misplacement, damage or destruction of physical documents. Others implication is cost considerations, where the BIM method requires an initial investment for software and training but holds the potential for long-term cost savings through improved efficiency and reduced maintenance costs. In contrast, the paper-based method may have lower upfront costs but could incur higher expenses over time due to inefficiencies, data loss risks, and increased maintenance costs.

CONCLUSION

A pivotal outcome of the study involves the integration of survey data and maintenance parameters into the 3D model in Revit software. Subsequently, Naviswork Manage software is utilized to simulate maintenance processes, providing insights into expected timeframes and durations. This approach enhances the transparency and efficiency of the maintenance process. The existing challenges, such as data management inconsistency stemming from handwritten documentation, contribute to the high costs and time required for updating maintenance schedule data. Nevertheless, it is anticipated that leveraging BIM applications for information management will alleviate these challenges, leading to cost reduction and increased efficiency. The incorporation of BIM also plays a crucial role in enhancing the efficiency and speed of maintenance operations in construction through automation (Z.-A. Ismail, 2020). Based on the case study, there are several recommendations for future research aimed at expanding and assessing the efficiency of integrating Revit and Naviswork Manage software within the maintenance management system of Universiti Malaysia Perlis (UniMAP), especially on Unicit Alam building. To address the limitation identified in the case study regarding the lack of precise defect locations in Revit software, future research should focus on enhancing the system's capabilities. Specifically, efforts can be directed towards developing a feature that generates accurate defect locations within components, whether in 3D plans or floor plans. The integration of BIM methodology into facility maintenance management, utilizing Revit and Naviswork Manage software, unquestionably assists building owners in understanding maintenance needs and becomes pivotal in planning and visualizing maintenance tasks. Although BIM technology has primarily been employed for modelling purposes, it can also be utilized to examine particular defects in building components (Ismail, 2021). Thus, this integrated system's applicability extends not only within Universiti Malaysia Perlis (UniMAP) but also extends to other universities or any high-rise buildings that require systematic and periodic facility maintenance.

The research reported here was conducted in Malaysia and so its findings may have reflected Malaysia environment only. However, the principles discussed tend to cut across boundaries and may be replicable elsewhere, albeit with circumspect modifications. Regarding the above findings, this research will concentrate on the development of a new system to integrate the BIM technology to improve the maintenance planning practices at UniMAP. Other limitations also can arise such as integration challenges in maintenance management when implementing BIM technology due to its dependency on compatible software. The absence of suitable software poses a significant obstacle to the seamless adoption of BIM technology in maintenance management processes. Thus, the development and implementation of standardized protocols and new interfaces that enhance interoperability between BIM software and maintenance management systems.

Presently, the implementation of ICT tools in the new system is the better improvement to lead the tremendous saving in budget, and to receive the precise data in handling the time planning and control. The facility maintenance management practices and the BIM technology application highlight the original contribution in improving maintenance planning in the future as follows:

i. The system application enable technician to reduce the time taken for assessing the condition of the structure and its components using the time simulation index compared to use the traditional system;

ii. The system is completed with the decision making process in planning to identify the structural defects and draw the conclusions including the selection of an appropriate material or refurbishment method;

iii. It has minimised the gap of isolation for the professional collaboration and communication at UniMAP facility maintenance projects; and

iv. Database information also provides a large capacity for maintenance management data storage, and is paired with an independent Naviswork database management system for obtaining the effective planning technique based on the risk of defects on the maintenance workflow.

REFERENCES

1. Aziz, N. D., Nawawi, A. H., & Ariff, N. R. M. (2016). Building Information Modelling (BIM) in Facilities Management: Opportunities to be Considered by Facility Managers. Procedia - Social and Behavioral Sciences, 234, 353–362. https://doi.org/10.1016/j.sbspro.2016.10.252
2. Bernama. (2023, June 20). Public Works Ministry aiming to maximise use of IBS, BIM in construction sector. https://www.edgeprop.my/content/1906410/public-works-ministry-aiming-maximise-use-ibs-bim-construction-sector
3. Chen, J., Lu, W., Fu, Y., & Dong, Z. (2023). Automated facility inspection using robotics and BIM: A knowledge-driven approach. Advanced Engineering Informatics, 55, 101838. https://doi.org/10.1016/j.aei.2022.101838
4. Faqih, F., & Zayed, T. (2021). Defect-based building condition assessment. Building and Environment, 191, 107575. https://doi.org/10.1016/j.buildenv.2020.107575
5. Firdaus Razali, M., Azam Haron, N., Hassim, S., Hizami Alias, A., Nahar Harun, A., & Salihu Abubakar, A. (2019). A Review: Application of Building Information Modelling (BIM) over Building Life Cycles. IOP Conference Series: Earth and Environmental Science, 357(1), 012028. https://doi.org/10.1088/1755-1315/357/1/012028
6. Gao, X., & Pishdad-Bozorgi, P. (2019). BIM-enabled facilities operation and maintenance: A review. Advanced Engineering Informatics, 39, 227–247. https://doi.org/10.1016/j.aei.2019.01.005
7. Gong, P., Zeng, N., Ye, K., & König, M. (2019). An Empirical Study on the Acceptance of 4D BIM in EPC Projects in China. Sustainability, 11(5), 1316. https://doi.org/10.3390/su11051316
8. Hamil, S. (2021, September 9). BIM dimensions – 3D, 4D, 5D, 6D BIM explained. https://www.thenbs.com/knowledge/bim-dimensions-3d-4d-5d-6d-bim-explained
9. Hoang, G. V., Vu, D. K. T., Le, N. H., & Nguyen, T. P. (2020). Benefits and challenges of BIM implementation for facility management in operation and maintenance face of buildings in Vietnam. IOP Conference Series: Materials Science and Engineering, 869(2), 022032. https://doi.org/10.1088/1757-899X/869/2/022032
10. Ismail, Z.-A. B. (2021). Towards a BIM-based approach for improving maintenance performance in IBS building projects. Engineering, Construction and Architectural Management, 28(5), 1468–1490. https://doi.org/10.1108/ECAM-07-2020-0508
11. Li, S., Zhang, Z., Lin, D., Zhang, T., & Han, L. (2023). Development of a BIM-based bridge maintenance system (BMS) for managing defect data. Scientific Reports, 13(1), 846. https://doi.org/10.1038/s41598-023-27924-6

12. Matarneh, S. T., Danso-Amoako, M., Al-Bizri, S., Gaterell, M., & Matarneh, R. (2019). Building information modeling for facilities management: A literature review and future research directions. Journal of Building Engineering, 24, 100755. https://doi.org/10.1016/j.jobe.2019.100755
13. Oluleye, I. B., Oyetunji, A. K., Olukolajo, M. A., & Chan, D. W. M. (2023). Integrating building information modelling for improving facility management operations: A fuzzy synthetic evaluation of the critical success factors. Journal of Facilities Management, 21(2), 201–220. https://doi.org/10.1108/JFM-06-2021-0066
14. Ruslin, Mashuri, S., Abdul Rasak, M. S., Alhabsyi, F., & Syam, H. (2022). Semi-structured Interview: A Methodological Reflection on the Development of a Qualitative Research Instrument in Educational Studies.
15. Shaikh, Y., Sawant, V., Satam, A., Waingankar, H., & Joshi, D. M. (2020). REVIT STRUCTURE. International Journal of Architectural Design and Management. https://doi.org/10.37628/.v3i2.707
16. Teicholz, P. M., & International Facility Management Association (Eds.). (2013). BIM for facility managers. John Wiley & Sons [u.a.].
17. Tengku Ahmad, T. N., & Abd Rasid, S. Z. (2021). Implementation of Building Maintenance Management System in an Organization. Journal of Advanced Research in Technology and Innovation Management 1, Issue 1 (2021) 1-8.
18. Yalcinkaya, M., & Singh, V. (2014). Building Information Modeling (BIM) for Facilities Management – Literature Review and Future Needs. In S. Fukuda, A. Bernard, B. Gurumoorthy, & A. Bouras (Eds.), Product Lifecycle Management for a Global Market (Vol. 442, pp. 1–10). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-45937-9_1
19. Espindola, D. B., Fumagalli, L., Garetti, M., Pereira, C. E., Botelho, S. S. C. and Henriques, R. V. (2013), "A Model-based Approach for Data Integration to Improve Maintenance Management by Mixed Reality", Computers in Industry, Vol. 64 No. 2013, pp. 376-391.
20. Miettinen, R. and Paavola, S. (2014). Beyond the BIM Utopia: Approaches to the Development and Implementation of Building Information Modeling, Automation in Construction, Vol. 43 No. 2014, pp. 84-91.
21. Kapoor, D. R. and Saigal, P. (2013). Research Methodology: Methods and Techniques, REGAL Publications, New Delhi, India.
22. Hesse-Biber, S. N. and Leavy, P. (2011), The Practice of Qualitative Research, SAGE Publications, Thousand Oaks, California.
23. Tainton, B. E. (1990). The Unit of Analysis 'Problem' in Educational Research, Journal of Educational Research, Vol. 6 No. 1, pp. 4-19.
24. Gnanarednam, M. and Jayasena, H. S. (2013). Ability of BIM to Satisfy CAFM Information Requirements, in The Second World Construction Symposium 2013: Socio-Economic Sustainability in Construction, Ceylon Institute of Builders, Colombo, Sri Lanka, pp. 12-21.
25. Liu, R. and Issa, R. (2012). Automatically Updating Maintenance Information from a BIM Database, in International Conference on Computing in Civil Engineering, ASCE, Florida, USA, pp. 373-380.
26. Costin, A., Shaak, A. and Teizer, J. 2013. Development of a Navigational Algorithm in BIM for Effective Utility Maintenance Management of Facilities Equipped with Passive RFID. In 2013 International Workshop on Computing in Civil Engineering, Los Angeles, California, ASCE, Florida, USA, pp. 653-661.
27. Chen, H., Hou, C. and Wang, Y. (2013). A 3D Visualized Expert System for Maintenance and Management of Existing Building Facilities using Reliability-based Method, Expert Systems with Applications, Vol. 40 No. 2013, pp. 287-299.
28. Kwon, O., Park, C. and Lim, C. (2014). A Defect Management System for Reinforced Concrete Work Utilizing BIM, Image-Matching and Augmented Reality, Automation in Construction, Vol. 46 No. 2014, pp. 74-81.