An Investigation into Appropriate Maintenance Strategy Between Preventive and Predictive for Buildings in South Africa

Maphutha Letsau Khutso
Department of Construction Management and Quantity Surveying
University of Johannesburg
Johannesburg. RSA
letsaukhutso@gmail.com

Morena William Nkomo and Stephan Molusiwa Ramabodu
Department of Construction Management and Quantity Surveying
University of Johannesburg
Johannesburg. RSA
mnkomo@uj.ac.za, molusiwar@uj.ac.za

Abstract

Building maintenance is an important building need that a building requires to serve its design purpose. Most buildings are decaying because of lack of maintenance. Building owners fail to prevent buildings from decaying because of lack of maintenance strategies knowledge. This paper look at the appropriate maintenance strategy between preventive and predictive maintenance for south African house. This is achieved through determining building components that require preventive and predictive maintenance strategy in order for the building to perform its function without any harm. Conclusions were made based on the importance of the building components on the building.

Keywords
Building Maintenance, Preventive Maintenance, Predictive Maintenance, Strategy.

Introduction.
Building maintenance is an important program for the sustainability of infrastructural development. It plays an important role among other activities in building operations (Zulkarnain et al. 2011). There are several definitions of maintenance in the previous literature. According to Ali et al. (2013), describe maintenance as the technical as well as managerial processes that guarantee that every component of the building is in a suitable state to carry out the intended function.

As to BS 3811(1984), maintenance encompasses all technical and related measures taken to either preserve an object or return it to a state where it can fulfil its intended purpose. According to Chanter and Swallow (2006), maintenance is a collection of actions done to either conserve or restore an item to a usable state. Maintenance can also be defined as an ongoing process that keeps a facility in optimal condition and safe for daily usage (Mydin 2015). According to BSI (1964), maintenance is defined as work done to bring the facility that is, each component of the site or building back to a satisfactory level.

Work performed with the purpose to protect, reclaim, or enhance each component of a building, including its services and surroundings, to presently suitable quality and maintain the economic and aesthetic value of the building" is how (Seeley 1976). About medication, maintenance to building can be associated with medication that the body requires to heal the illness. Out of the different explanations mentioned above by different researchers, all

definitions defines maintenance as aiming to restore and to keep the building's original shape and to serve its initiated purpose.

Aim of the study
- To determine building components that require preventive and predictive maintenance strategy.
- To determine an appropriate maintenance strategy between preventive and predictive for buildings in South Africa.

Literature Review.

While designing maintenance-free buildings is highly desired, but rarely possible for a building to not require maintenance. However, there is much that can be done during the design phase to minimize the quantity of maintenance that will be required later on. Depending on the buildings use, the environment, the materials and construction techniques used, and other factors, all building components decay at different rates (Seeley 1976). Maintenance starts the day the builder leaves the site. Throughout a building's existence, the quantity of maintenance needed will depend on a number of factors, including the design, craftsmanship, materials, and applications of the building.

Different strategies have been applied previously to mitigate the high demand of maintenance on buildings. This high demand has been seen as a lack of a proper sustainable maintenance strategy on the building. Although there are different types of maintenance strategies that exist, buildings are not immune to maintenance. For us to apply the right maintenance strategy, it is important to analyze the current maintenance strategy in order to enhance the success potential of implementing the best maintenance on buildings depending on different features which include, design materials, etc. In this paper, we look at only two maintenance strategies, preventive and predictive maintenance.

1.1 Importance of preventive maintenance.

Preventive maintenance as a maintenance management program is defined differently by different authors, but all definitions are time-driven. Preventive maintenance is a useful strategy for improving the durability and quality of a device and its parts (Rao 1992). Recently inadequate maintenance performance has been associated with a lack of preventative maintenance (Au-Yong et al. 2014). Au-Yong et al. (2014), in his research titled "Preventive maintenance characteristics towards optimal maintenance performance: A case study of office buildings" proposed the implementation of preventive maintenance to address the inadequacy of preventive maintenance. According to Rastegari, & Salonen (2015), preventive maintenance is carried out on a regular schedule or by predetermined guidelines in order to reduce the likelihood of an item failing to function or deteriorating.

Miya & Grobbelaar, (2015) pointed out that preventative maintenance aims to avert major malfunctions and guarantees that they continue using regular examination and repair at optimal efficiency. Furthermore, it prevents malfunctioning by indicating the necessity of maintenance before any failure. This is possible because preventive maintenance keeps the buildings and machine parts in good working order through routine chores including inspection, monitoring, cleaning, lubrication, adjustment, alignment, repair, replacement, and maintenance before faults or machine failures arise (Moghaddam & Usher 2010) and (Wang & Christer 2000). This according to Eti et al. (2006) prolong the life of elements and enhances their effectiveness.As a known fact, buildings are never immune to maintenance and with time, system elements start to deteriorate with parts of the building decaying, while also encountering excessive expenses, like urgent maintenance when a breakdown occurs, this necessitates the implementation of preventive maintenance (Au-Yong et al. 2014).

1.2 Building components that require preventive maintenance.

A building is made up of various components, each serving a distinct purpose. These basic components cooperate so that one shortcoming frequently causes a chain reaction that is too damaging to ignore. Ignoring these signals could lead to more severe, potentially fatal problems down the road, including a building's collapse or system failure or most severe cases, as well as higher maintenance expenses overall. Preventive maintenance plays a significant role on the building elements, as most of them require to be inspected/monitored in order to detect any deterioration before malfunctioning. Building components that require preventive maintenance include:

Foundation

A foundation is a combination of several materials such as soil, concrete, steel, wood, plastic, and others that are intended to function as a sturdy base for a superstructure. It is advisable to embark on routine inspection in order to maintain the foundation.

1.2.1   Exterior features.
Building exterior features, are features that always exposed to environmental factors such as the sun, rain, wind etc. most of this features include, external wall paint, windows, door frames, doors, roof sheeting, gutters, downpipes etc. When it comes to exterior features, it's best to focus on preventive maintenance to lessen the severity of degradation (Rockwell 2023).

1.2.2   Interior features.
Interior features of a building are features that cannot be accessible from outside the building. These features comprised of internal wall paint, tiles, ceiling door frames and doors, electrical cables, bulbs etc. Same as exterior features, interior features are easily prevented from decay through the utilization of preventive maintenance (Rockwell 2023).

1.2.3   Fittings.
Fittings comprise of a variety of elements that outfit or equip a structure, such as doors, windows, plumbing, and sanitary fixtures, as well as electrical, gas, and built-in fixtures. These include benches, cupboards shelving, racks, seats, counters, notice boards, signs and nameplates, coat rails and hooks, mirrors, wall hatches, daises, and stages. Routine inspections to evaluate the state of the fixtures, replacement of broken fixtures, and repair of certain fixtures like clearing obstructions in the pipes, patching leaks, caulking fissures, etc are all necessary to maintain the fittings (Rockwell 2023).

1.3 Importance of Predictive Maintenance.
Similar to preventive maintenance, predictive maintenance has a couple of definitions by different authors. Predictive maintenance, or PdM, is a proactive maintenance approach that entails ongoing equipment analysis and monitoring during regular operations to find defects and repair them before they cause malfunction (Ramadan, 2023). According to Mobley, (2002) predictive maintenance involves tracking the vibration of spinning machinery in an effort to identify possible faults early on and prevent a total breakdown. Furthermore, Elliott, (2022) pointed out that predictive maintenance utilizes both current and past information from linked building systems and equipment, with technology models performance that keeps an eye on circumstances and foresees equipment or system failure before it happens. According to Bouabdallaoui et al. (2021) predictive maintenance works by applying data analytics tools to process operation data received from sensors.

Predictive maintenance offers the maintenance personnel a chance to prevent unanticipated breakdowns, lower maintenance expenses and fines, and enhance resident safety and well-being (Bouabdallaoui et al. 2021). Nevertheless, there are several obstacles to overcome when putting a predictive maintenance strategy into practice, including linking physical assets, gathering useful data, and creating precise prediction algorithms. These days, most maintenance procedures are corrective and preventative; predictive maintenance is only used in critical circumstances (Cachada et al. 2018). In the context of buildings, predictive maintenance makes use of data from many systems and parts of the structure, such the lighting, security, and HVAC (heating, ventilation, and air conditioning).

1.4 Building components that requires predictive maintenance.

HVAC system.
HVAC (heating, ventilation, and air conditioning) systems are essential for maintaining building inhabitants' comfort and security. HVAC systems can be monitored and maintained by means of predictive maintenance, which includes performing air filter changes, keeping an eye out for refrigerant leaks, and keeping track of compressor and motor performance (Gupta 2023)

1.4.1   Lighting.
Lighting is a crucial component of building functions for power efficiency and occupant comfort. According to Gupta (2023), lighting systems can be monitored with predictive maintenance to identify problems like burnt-out bulbs or circuit breakdowns.

1.4.2   Refrigeration system.

Refrigerant lines, condensers, evaporators, and compressors are some of the parts of refrigeration systems. Gupta, (2023), pointed out that predictive maintenance can be carried out on these components by monitoring temperature, voltage, and oil analysis. The other pivotal role of implementing preventive maintenance is to ensure that, problems such as leaks, compressor malfunctions, and blockages prior to them resulting in costly repairs or downtime are addressed.

1.4.3   Electrical system.

Electrical system are important elements of commercial buildings and malfunctions can have a dire repercussion. Electrical systems can be monitored with predictive maintenance to find problems like circuit breaker failures and variations in voltage (Gupta 2023).

1.4.4   Fire safety system.

Building safety depends on fire safety systems, which include smoke detectors, sprinklers, and sirens. According to Gupta, (2023), to These systems may be monitored using predictive maintenance, which can identify problems like blocked sprinkler heads or broken detectors.

1.5 Benefits of preventive and preventive maintenance.

Preventive maintenance	Predictive maintenance
Reduced downtime	Reduce downtime
Increased efficiency	Enhance operational efficiency
Cost savings	Cost saving
Improved safety	Enhance safety
Extended equipment life	Enhance comfort and satisfaction.

1.6 Comparison of preventive and predictive maintenance.

Preventive maintenance	Predictive maintenance
Is planned maintenance	Is proactive maintenance
Uses scheduling software frequently to inform groups or individuals of impending equipment repair	Employs predictive technologies to plan corrective maintenance and handle possible issues before they become serious
Provides you with accurate information for property health and productivity.	Increases total inventory efficiency by preventing machine parts from being overworked or prematurely replaced.
Frequently necessitates machine downtime.	Hardly requires machine downtime, and when it does, it's often only for a short period
Usually makes use of routine processes, guides, and maintenance checklists.	Uses sophisticated instruments such as oil analysis, vibration analysis, and infrared thermography together with data analytics software and occasionally sensor devices

2.   Methodology.

The study engaged in a three-stage process to achieve its objectives:

Stage 1: The first step of the methodological approach was the identification of the importance of preventive and predictive maintenance through a review of extant maintenance strategies using publications from Scopus, Web of Science, and Google Scholar databases, Research Gate, Emerald Insight. As stated by Onososen and Musonda, (2022) Scopus is reputable for its wide coverage, while Web of science has more catalogues of important journals than other databases Nguyen Van et al. (2021). A critical review approach, which focused on the importance of preventive and predictive maintenance identified in the extant publications, incorporated documents from journals, conferences, and book chapters to eliminate bias.

Stage 2: Stage 2 is expanded into components of preventive and predictive maintenance from the literature review process were presented for validation and representativeness in the life maintenance. The inputs from the discussion were adopted to determine an appropriate maintenance strategy between preventive and predictive for buildings in South Africa.

Stage 3: The data gathered from previous literatures and then analyzed. This stage sum-up the paper by presenting the conclusion of the study as well as presenting the recommendations for the study. This article is based on a literature reviews whose goal is to firstly to determine building components that require preventive and predictive maintenance strategy and to determine an appropriate maintenance strategy between preventive and predictive for buildings in South Africa.

Conclusions.

The primary objectives of predictive and preventive maintenance are to minimise the cost of response to failures and improve asset reliability. Both types of maintenance are considered scheduled maintenance since orders for repairs are prepared well ahead of the actual date of maintenance. Preventive maintenance is conducted on a regular basis whereas predictive maintenance is scheduled according to equipment conditions. Predictive maintenance entail monitoring the state and productivity of tools utilizing advanced technology and data analysis. Its objective is to anticipate possible faults and enable proactive maintenance procedures, as a result of mitigating unexpected downtime.

Conversely, preventive maintenance entails planned inspection cleaning, and repairs which aims to stop faults prior to happening. It develops maintenance schedules based on past performance and manufacturer guidelines to ensure consistent service and handle observed hazards.

Findings.

Both preventive and predictive maintenance play an important role on the components of the building, more specially because the most building comprise of preventive and predictive elements which requires maintenance of different strategy. Preventive strategy is mostly important because it has components that predictive strategy is not applicable to such as foundations, paint, roof, tiling etc. Secondly preventive maintenance is significant because it can also be applicable to other building components that requires predictive strategy.

Recommendation.

The primary objective of this study was to determine an appropriate maintenance strategy between preventive and predictive for buildings in South Africa. This included determining building components that require preventive and predictive maintenance strategies. Based on the literature both strategies play different roles on the building both having an essential impact on the operation of the building. It is therefore advisable that both strategies be considered as follows.

- Preventive maintenance should be applied to components that require inspections and monitoring such as foundations, roof, wall, paint, tiles doors, windows, doo frames etc.
- While predictive maintenance should be applied to components that makes use of advance technology and analyse data from many systems and parts of the structure

References

Ali, A. S., Keong, K. C., Zakaria, N., Zolkafli, U., & Akashah, F. , The effect of design on maintenance for school buildings in Penang, Malaysia. *Structural Survey*, *31*(3), 194–201, 2013. doi:10.1108/ss-10-2012-0030.

Parida, A., &. Kumar, U., Maintenance performance measurement (MPM) system. *Springer Series in Reliability Engineering*, 459–478,2006. doi:10.1007/978-1-84800-011-7_19

Chanter, B., & Swallow, P. (2006). *Building Maintenance Management*. Oxford: Blackwell.

BSI. (1964). Glossary of maintenance management terms in Terotechnology. *Glossary of Maintenance Management Terms in Terotechnology*. doi:10.3403/00122684

Seeley, I. H., (1976). *Building Maintenance*. London: Macmillan

Rao, S.S. (1992) Reliability-Based Design. McGraw-Hill, New York.

Au-Yong, C. P., Ali, A. S., & Ahmad, F. (2014). Preventive maintenance characteristics towards optimal maintenance performance: A case study of office buildings. *World Journal of Engineering and Technology*, *02*(03), 1–6. doi:10.4236/wjet.2014.23b001

Rastegari, A., & Salonen, A.,   Strategic Maintenance Management: Formulating Maintenance Strategy. International Journal of COMADEM, 18, 5-14, 2015.

Miya, L.U.N.G.I.S.A.N.I. and Grobbelaar, S.A.R.A. (2015). Risk-Based Maintenance of Physical Assets of Water Infrastructure: A Case Study of a Municipality. Proceedings of International Association for Management of Technology.

Moghaddam, K.S. and Usher, J.S., Optimal Preventive Maintenance and Replacement Schedules with Variable Improvement Factor. Journal of Quality in Maintenance Engineering. 16, 271-287, 2010.

Wang, W. and Christer, A.H., Towards a General Condition Based Maintenance Model for a Stochastic Dynamic System. The Journal of the Operational Research Society, 51, 145-155, 2000. http://dx.doi.org/10.1057/palgrave.jors.2600863

Eti, M.C., Ogaji, S.O.T. and Probert, S.D., Development and Implementation of Preventive-Maintenance Practices in Nigerian Industries. Applied Energy, 83, 1163-1179,2006. http://dx.doi.org/10.1016/j.apenergy.2006.01.001

Spinella, M. (2023, May 10). Retrieved from https://www.linkedin.com/pulse/importance-benefits-predictive-preventive-maintenance-mirko-spinella/

Rockwell. (2023). What is preventive maintenance? The Complete Guide to PM. Retrieved from https://fiixsoftware.com/maintenance-strategies/preventative-maintenance/#:~:text=Common%20examples%20of%20preventive%20maintenance,on%20the%20equipment%20being%20maintained.

Lee, H. H., & Scott, D. , Overview of maintenance strategy, acceptable maintenance standard and resources from a building maintenance Operation Perspective. *Journal of Building Appraisal*, *4*(4), 269–278,2009. doi:10.1057/jba.2008.46

Bouabdallaoui, Y., Lafhaj, Z., Yim, P., Ducoulombier, L., & Bennadji, B. (2021). Predictive maintenance in building facilities: A machine learning-based approach. *Sensors*, *21*(4), 1044. doi:10.3390/s21041044

Cachada, A., Moreira, P. M., Romero, L., Barbosa, J., Leitno, P., Gcraldcs, C. A. S., … Moreira, A. H. J. (2018). Maintenance 4.0: Intelligent and predictive maintenance system architecture. *2018 IEEE 23rd International Conference on Emerging Technologies and Factory Automation (ETFA)*. doi:10.1109/etfa.2018.8502489

Gupta, M. (2023). Predictive maintenance: A comprehensive guide. Retrieved from https://www.zenatix.com/predictive-maintenance-a-comprehensive-guide/#Industries_that_are_adopting_predictive_maintenance

Onososen, A.O.; Musonda, I. Research Focus for Construction Robotics and Human-Robot Teams towards Resilience in Construc-tion: Scientometric Review. J. Eng. Des. Technol. 2022.ahead of print.

Biography.

Maphutha Letsau Khutso is a scholar at the University of Johannesburg, currently registered for master's in construction management. He bagged his BSc Honours degree in Quantity Survey, Certificate in Construction Management, and National Diploma in Building from the Department of Construction Management and Quantity Surveying at the University of Johannesburg. He is currently employed as a Tutor in his department, where he assisted in teaching. This employment gave the platform for an increased interest in research.

Morena William Nkomo is a Senior lecturer in the Department of Construction Management and Quantity Surveying in the University of Johannesburg South Africa. He earned his PhD in Engineering Management (University of Johannesburg) , N.Dip Building, B. Tech Construction Management and M. Tech in Construction Management. He has published conference papers and book chapters. Morena has completed research projects with South African construction industry in Human Resource Management and Retention of employees, human capital and mentoring of employees in the construction industry.

Stephan Molusiwa Ramabodu is a Professional Quantity Surveyor and Associate Professor in the Department of Construction Management and Quantity Surveying in the Durban University of Technology , South Africa. Qualification(s) PhD, MLPM, BSc(QS) Research Interests Procurement, estimates, low cost housing and contract law.