The Asian Review of Civil Engineering
ISSN: 2249-6203 (P); 2583-7893 (E)
Vol.12 No.2, 2023, pp.1-7

DOI: https://doi.org/10.51983/tarce-2023.12.2.3797

Maintenance of Public Buildings in the Central Region of Ghana

David Mensah, Zakari Mustapha, Benjamin Boahene Akomah, Peter Aidoo and Chris Kurbom Tieru
Department of Construction Technology and Management, School of Built and Natural Environment,
Cape Coast Technical University, Cape Coast, Ghana
E-mail: mustapha.zakari@cctu.edu.gh
(Received 12 October 2023; Accepted 21 October 2023; Available online 4 November 2023)

Abstract - **Building maintenance ensures functionality, stability, and appearance and extends the structure's lifespan. This study examined suitable maintenance strategies for public buildings in the Central Region of Ghana. Out of four hundred (400) questionnaires administered to maintenance officers and personnel of public buildings in the Central Region, two hundred and ninety-six (296) were returned, representing 74%. The findings showed that the respondents considered the deterioration of buildings and the maintenance quality as very important factors. The Kaiser-Meyer-Olkin (KMO) measure of sample adequacy for p-values varies from 0.914 to 0.971, indicating that the constructs or factors strongly impact the prediction of building maintenance management. Further findings show that all the constructs or factors have strong (0.700 – 0.800) factor loadings, indicating a strong influence in predicting building maintenance management. Only one construct or factor (maintenance budgeting and auditing) with one variable (end-of-job documentation) had strong (0.940) factor loadings. Three constructs/factors (maintenance techniques, maintenance culture, and maintenance management) were found to have strong (7.00 - 8.00) factor loadings, which strongly influence predicting building maintenance management. It is concluded that attention should be paid to the developed constructs or factors in any future work in the Central Region and should involve Development Officers.**
Keywords: **Building Appearance, Building Performance, Deterioration Level, Inspections, Monitoring, Technical Skills, Strategic Plans**

I. INTRODUCTION

Maintenance is pivotal in building performance by guaranteeing facilities' long-term functional, structural, and aesthetic integrity. As highlighted, it deserves strategic placement within an organisation's management structure [1,2]. In a society's initial assessment of service quality, the appearance of public buildings is important [3]. The operational aspect of maintenance requires technical proficiency, whereas effective managerial decision-making involves understanding what decisions to make and how to make them [4]. Services, repairs, and replacements are included in maintenance chores and remedial or preventative actions taken before failure [5,6]. Although the tactical strategies and objectives of the maintenance department and organisation should also be considered, maintenance employees are largely focused on technical difficulties [7]. Effective maintenance implementation can be difficult in organisations and necessitates complete top-level management commitment and involvement [8, 9, 10]. According to [11], specific characteristics affect the outcome of a maintenance project, such as the contractor's personality and capacity to gauge the pace of deterioration, offer maintenance guidance, and consider financial ramifications. Designing, planning, and calculating maintenance and performance measurement plans are essential components of a successful maintenance project [11]. In addition, honesty, integrity, and coordination abilities are crucial. This study sought to determine the best maintenance practices for government structures in the Central Region. The following section discusses building maintenance tactics.

A. Management of Building Maintenance

Building maintenance management now encompasses a variety of critical management functions, including strategic and operational management, rather than purely technical ones [12]. Consequently, strategic management is essential for maintenance. [13], "strategic management encompasses the top management's analysis of the organisation's environment prior to the formulation of a strategy, as well as the plan for implementing and controlling the strategy." At a university, executive management oversees strategic management, and its key role in connection with maintenance management is to create maintenance procedures that direct program development and strategy selection [14].

B. Strategic Management's Key Functions and Importance

1. An organisation's maintenance objectives should be in harmony with its core objectives, as they profoundly influence the maintenance management processes [12].
2. An organisation's strategic objectives and the focus placed on the condition of its facilities determine the significance of a maintenance division inside that organisation [15] and
3. Managing strategically in maintenance entails formulating maintenance policies, defining strategic directions, approving budgets, and allocating essential resources for maintenance purposes.

Organisations outsource maintenance work because only authorised contractors may carry out necessary maintenance inspections and testing [16]. Although monthly internal testing of fire alarm systems is conducted, only one licenced company is permitted to conduct smoke detector examinations every two years. Additionally, a licenced business or licenced individual must perform testing and inspections for objects such as lifts, boilers, and backflow prevention [16]. [17] defined the control of a system's deterioration process or its return from a failure state to its operational condition. According to [18], maintenance scheduling entails matching jobs with resources and sequencing them to be performed at particular times.

[10] indicated that maintenance work requires significant investment in time, money, manpower, and resources, as well as the commitment of all stakeholders. [9] argued that organisations must be willing to change their mindset and embrace new procedures and cultural shifts to implement maintenance management systems successfully. To sustain ISO 9000 certification, [19] listed some critical success variables that must be given the necessary attention: teamwork, continuous improvement, acquaintance with ISO standards, performance assessment, communication, and the composition of the top management and staff.

C. Maintenance Strategies

[20] define a maintenance plan as a technique for converting corporate objectives into maintenance goals. They also described it as a methodical approach to maintaining facilities and equipment, which can vary from one facility to another. A maintenance plan is described by [21] as a rule of reasoning that determines the sequence of maintenance procedures to be carried out in accordance with the level of system deterioration and the permissible exploitation thresholds. The most basic conventional maintenance programme is corrective maintenance, which entails fixing equipment after it malfunctions or breaks down [22].

D. Application of a Maintenance Plan

For maintenance managers, it might not be easy to develop and implement efficient maintenance strategies inside an organisation [20]. Each organisation has unique challenges and obstacles depending on its maintenance philosophies. Even businesses that make every effort to follow maintenance standards may face challenges due to the maintenance culture [23]. [24] emphasised the importance of tactically implementing a maintenance plan, which includes several different elements, such as the purpose, goals, maintenance strategies, objectives, and regulations. According to [25, 26, 27], the steps involved in implementing a maintenance strategy include defining the strategy, creating objectives and goals, and creating policies and procedures.

1. Creating a maintenance plan for each piece of equipment or component or identifying the necessary tasks.
2. Resources, such as labour, replacement parts and tools for carrying out a specific maintenance strategy successfully; and
3. Implementing the maintenance strategy by efficiently allocating workers and operating the appropriate systems to manage all resources.

E. Optimisation of Maintenance Strategy Choices

In any given business, choosing maintenance tactics for a particular piece of equipment involves making a difficult judgment based on several factors. For instance, a maintenance decision support system (MDSS) at the plant level can decrease unplanned downtime, boost equipment availability, and manage resources to maximise output. Additionally, maintenance methods, such as plant asset management (PAM), RCM (reliability-centred maintenance), and TPM (total productive maintenance) can reduce maintenance costs. Organisations may also invest in corporate information systems, such as enterprise resource planning (ERP), to handle maintenance tasks. [28] contended that maintenance strategies and practices are critical in accomplishing organisational maintenance objectives. According to [20], maintenance strategies involve setting off particular maintenance procedures in response to specified events, such as failure, the passage of time, or a condition. According to [18], a maintenance plan must be created in line with business goals and centred on a full understanding of the maintenance function in the overall business strategy. Making strategic decisions on organisational structure, maintenance procedures, assisting systems, and outsourcing possibilities is part of creating a maintenance plan. Following these decisions, medium-term plans are developed for capacity and workforce planning, followed by scheduling implementation-related activities and ongoing performance evaluation for feedback and improvement.

Management must be aware of the maintenance performance to plan and direct the maintenance procedure [29]. The main topics of this information should be the efficacy and productivity of the procedure for maintenance, as well as its operations, organisation, co-operation, and coordination with other organisational units. The expansion of preventive maintenance practices in public management companies has reduced public spending on repairs and restorations [30]. To effectively manage the maintenance of reserve assets, computerised maintenance management tools are available in the commercial industry [31].

According to [32], the organisation of the documentation and the data it contains should be used as evidence of the management of the maintenance programme, cost-benefit analyses, the lessening of uncertainty in programme support and future service planning as well as in the design, planning, and execution of maintenance services. [32] recommended that the maintenance programme be implemented effectively, that planning, inspections, and maintenance be documented, and that indicators be used to gauge how effectively the services are delivered. According to [33], smooth management of maintenance methods avoids budget overruns and maintenance backlogs, leading to higher maintenance quality and overall building effectiveness. With less money spent, more actions, data, and knowledge can be monitored through the computerisation of maintenance management [34, 35].

II. METHODOLOGY

This study utilised quantitative data collection methods and identified two gaps in literature. The constructs and factors related to the topic of the study were derived from a literature review. Variables ranging from nine to 16 were identified for all constructs and factors. The questionnaire had two sections: one for the respondents' personal information and one for specifics on maintenance management techniques. The population comprised all public buildings in the Central Region, and a convenient sampling technique was employed. Questionnaires were distributed in hard copy to scattered construction firms within the region.

Questionnaires were administered to maintenance departments of government buildings in the Central Region of Ghana. Two hundred and ninety-six (296) out of four hundred (400) questionnaires were returned, representing 74% of the response rate. Excel and the Statistical Package for Social Sciences (SPSS) were used for data analysis. The findings were presented using descriptive statistics, which included frequencies, means, medians, and standard deviations. The constructs or factors that influence maintenance management strategies for public buildings were identified using principal component (PC) analysis, and loads of factors that exceeded 0.50 were collected for analysis. The constructs or factors and variables were prioritised to determine their significant roles in maintaining public structures in the Central Region.

III. FINDINGS OF THE STUDY

A. Descriptive Statistics

The findings of the study on staffing and training components for building maintenance management are presented in Table I. According to the study, the ranges for these constructs' means and standard deviations were 2.4832 to 3.7810 and 0.6242 to 0.8769, respectively. The study also found that the highest construct influencing maintenance management practices was the deterioration of buildings, with a mean of 3.7284 and a standard deviation of 0.8769.

The quality of building maintenance was the second-highest construct, with a mean score of 3.4927 and a standard variation of 0.7882. The component received a mean score of 2.5606 and a standard deviation of 0.7234, for which several respondents suggested using maintenance techniques. A maintenance information system was the fourth-highest construct, followed by efficient maintenance management. The maintenance culture was the least developed of the 14 building maintenance management constructs.

TABLE I MAINTENANCE MANAGEMENT OF PUBLIC BUILDINGS

Construct/Factor	N	M	MD	SD	R
Deterioration of buildings	296	3.7284	4.0000	0.8769	1
Quality of maintenance of buildings	296	3.4927	3.5714	0.7882	2
Maintenance techniques	296	2.5606	2.6920	0.7234	3
Maintenance information system	296	2.4832	2.6250	0.7202	4
Effective maintenance management	296	3.7810	4.0000	0.7080	5
Maintenance documentation	296	2.6400	2.6000	0.7058	6
Maintenance strategy	296	2.7407	2.8750	0.6693	7
Maintenance performance management	296	2.6179	2.6250	0.6657	8
Maintenance budgeting and auditing	296	2.6966	2.8000	0.6628	9
Maintenance management practice	296	2.7047	2.8333	0.6625	10
Staffing and training	296	2.7350	2.7857	0.6242	11
Maintenance culture	296	2.6870	2.6666	0.6077	12

N: The number of events, M the mean, MD the median, SD the standard deviation, and R the ranking

B. The Component Matrix, Bartlett's Test of Sphericity, and the Kaiser-Meyer-Olkin Measure of Sampling Adequacy

The data are sufficient for the analysis of variables, as made known in Table II by the KMO measure of the quality of the samples, which is higher than the statistically significant level (0.00 for building deterioration). Since the analysis of factors is correct, and the correlation matrix cannot be a matrix identity, Bartlett's sphericity test was denied.

TABLE II KAISER-MEYER-OLKIN AND BARTLETT'S TEST (KMOBT)

Kaiser-Meyer-Olkin Sampling Adequacy Measurement (KMOSAM)		0.946
Bartlett's Sphericity Test (BST)	Approx. Chi-Square (AC-S)	2846.192
	df	153
	Sig.	0.000

Strong factor loadings for all factors pertaining to building deterioration ranged from 0.636 to 0.937, exceeding the minimal threshold of 0.50. Out of the 14 variables, five had higher potential to cause damage: having dependable and maintainable equipment, with a factor loading of 0.739; ensuring regular servicing and repairs, with a factor loading of 0.736; placing excellent emphasis on the organisation's people and culture, with a factor loading of 0.728; providing adequate resources for maintenance, with a factor loading of 0.728; and identifying specialised tasks earlier, with a factor loading of 0.725.

Table III shows that the KMO measure for the building upkeep standard is 0.950, above the 0.000 significance threshold. This demonstrates that the sample number was adequate for scrutiny. At the 0.00 significance level, Bartlett's test of sphericity (BTS) failed, proving that the relationship matrix is not identical to the identity matrix. This implies a connection between the elements of the data set.

TABLE III KMOBT

KMOSAM		0.950
BST	AC-S	2447.877
	df	105
	Sig.	0.000

The loadings of the variables that affected the standard of building maintenance ranged from 0.654 to 0.770, exceeding the minimal requirement of 0.50. It follows that every aspect can impact the standard of building servicing. The relationship matrix is not an identity matrix, meaning the factors are correlated. The p-value of the KMO measure of 0.971 indicates that the sample size is sufficient for factor analysis. The p-value for BTS was less than 0.000, which means that the null hypothesis of sphericity was rejected. This means that these factors are not independent of each other.

TABLE IV KMOBT

KMOSAM		0.971
BST	AC-S	3510.355
	Df.	120
	Sig.	0.000

The factor loadings of all variables influencing the maintenance approaches were higher than the minimal criterion of 0.50, ranging from 0.726 to 0.821. Four variables, including CMMS, had particularly high factor loadings (0.821, 0.817, 0.814, and 0.804), indicating a stronger influence on maintenance practices.

Table V shows that the sample adequacy measure for the maintenance information system is acceptable because the p-value for KMO = 0.938 exceeds the significance threshold of 0.000. The rejection of BTS at a 0.00 significance level shows that the association matrix is not distinct.

TABLE V KMOBT

KMOSAM		0.938
BST	AC-S	2123.400
	Df	91
	Sig.	0.000

Strong factor loadings for every variable in the maintenance information system ranged from 0.657 to 0.740, above the minimum of 0.50. Five variables had a greater chance of influencing the maintenance information system: having a good organisational structure with a factor loading of 0.740, having a maintenance system audit with a factor loading of 0.740, having a budget situation that affects maintenance with a factor loading of 0.739, auditing the annual budget for maintenance with a factor loading of 0.737, and increasing the quality of maintenance work with a factor loading of 0.726.

The findings in Table VI show the value of the sample adequacy indicator for maintenance management because the KMO = 0.929, the p-value is higher than that of the 0.000 significance threshold. A further indication that the relationship matrix is not separate is the failure of Bartlett's examination of sphericity at the 0.00 significance level.

TABLE VI KMOBT

KMOSAM		0.929
BST	AC-S	1626.059
	df	36
	Sig.	0.000

The factor loadings for all variables under effective maintenance management ranged from 0.739 to 0.811, above the minimum criterion of 0.50. Three factors having a heavy budget for maintenance with a factor loading of 0.811, having a balanced and flexible maintenance plan with a factor loading of 0.808, and having a sinking fund budget for future needs with a factor loading of 0.801 have greater potential to affect effective maintenance management than the other six factors.

The information in Table VII demonstrates that the sample sufficiency metric is a poor indicator of the calibre of maintenance documentation. This is because the KMO test's p-value exceeded the significance level 0.000. Further evidence that the correlation matrix is not an identity matrix comes from the probability value for BTS is less than 0.000. A square matrix called an identity matrix has all of its diagonal members equal to one and all of its other elements equal to zero.

TABLE VII KMOBT

KMOSAM		0.925
BST	AC-S	1906.316
	df	55
	Sig.	0.000

Factor loadings for every variable in the maintenance manuals ranged from 0.693 to 0.794, above the minimal requirement of 0.50. With higher factor loadings (0.794, 0.787, and 0.784, respectively) than the other eight variables, three factors - having plans for future asset replacement, having a feedback mechanism on user satisfaction, and having original specifications for older buildings had a greater impact on maintenance documentation.

The findings presented in Table VIII reveal a KMO measure of sample adequacy at 0.952, surpassing the threshold of 0.5. This suggests that the correlation matrix is not an identity matrix, indicating interconnections between variables. Additionally, BTS, conducted at a 0.00 significance level, further supports this correlation among the variables.

TABLE VIII KMOBT

KMOSAM		**0.952**
BST	AC-S	2708.110
	df	120
	Sig.	0.000

Every variable in the maintenance plan has factor loadings between 0.646 and 0.778, higher than the required minimum of 0.50. This suggests that all variables might affect maintenance practices. The potential impact of six of the 16 variables, with factor loadings varying from 0.750 to 0.746, have the potential to have an even greater impact on the maintenance strategy: "have appropriate maintenance strategy," "have effective building maintenance management," "have strategic maintenance management," "have total maintenance management (TMM) framework," and "have maintenance procurement strategy."

According to Table IX, the p-value of KMO for determining the sample adequacy in maintenance performance management is 0.952, which is higher than the 0.000 significance level (0.00). Because the p-value was less than 0.000, the correlation matrix was not shown to be an identity matrix when BTS was rejected at a 0.00 significance level.

TABLE IX KMOBT

KMOSAM		**0.952**
BST	AC-S	2445.225
	df	105
	Sig.	0.000

The component loadings for all variables included in maintenance performance management ranged from 0.688 to 0.757, greater than the bare minimum of 0.50. The use of variable loadings of 0.757, 0.751, 0.750, 0.738, 0.733, and 0.731, respectively, six out of 15 variables, using short-term detailed maintenance planning, using a system to identify and assign personnel for specific tasks, using building inspection systems, having safety procedures for maintenance operations, compiling detailed maintenance procedures, and maintaining quality parameters, have a higher potential to influence maintenance performance management.

Table X demonstrates that for the KMO measure of adequate sampling, the p-value exceeded the 0.000 significance level, which was set at 0.00. This means that maintenance should be budgeted for and audited. At a significant threshold of 0.00, BTS was also ignored. It is not an identity matrix for the correlation matrix because the p-value is less than 0.000.

TABLE X KMOBT

KMOSAM		**0.925**
BST	AC-S	1906.316
	df	55
	Sig.	0.000

All variables used in maintenance budgeting and auditing exhibited significant factor loadings ranging from 0.00 to 0.940, above the minimum criterion of 0.50. The end-of-job documentation (factor loading of 0.940), properly documented guarantees and warranties agreed upon (factor loading of 0.830), maintenance records (factor loading of 0.775), periodic and recorded assessment (factor loading of 0.746), and original specifications for older buildings (factor loading of 0.742) were the five variables with the highest potential to affect the results.

The findings in Table XI show that the sample size is appropriate for maintenance management practices because the p-value of 0.934 for the KMO measure of sampling adequacy is higher than the 0.000 significance threshold. The corresponding correlation matrix is not an identity matrix, as shown by the failure of BTS at the 0.00 significance level.

TABLE XI KMOBT

KMOSAM		**0.934**
BST	AC-S	2342.092
	df.	105
	Sig.	0.000

Factor loadings for every variable included in the maintenance management practice ranged from 0.641 to 0.764, above the minimal requirement of 0.50. Six factors have a higher chance of affecting maintenance management practices: reservations for outside resources; using a system to identify and assign personnel for particular tasks; having tools, lifting equipment, and other equipment; using building inspection systems; having safety procedures for maintenance operations; and having material and spare parts stores. The factor loadings of these variables are 0.764, 0.763, 0.745, 0.742, 0.735, and 0.725, respectively.

Table XII findings show that sampling is adequate for staffing and training because the KMO measure of sampling adequacy possesses a p-value above the significance level of 0.000, at which point it achieves a p-value of 0.914. As a result, the study's findings can be applied to the entire population because the sample was typical of the overall population.

TABLE XII KMOBT

KMOSAM		0.914
BST	AC-S	1625.712
	df	66
	Sig.	0.000

All staffing and training-related variables, including understaffing and training, exhibited strong factor loadings higher than the minimum of 0.50, ranging from 0.647 to 0.769. Four factors had a greater influence on staffing and training opportunities than the other eight variables: providing staff with maintenance training, with a factor loading of 0.769; providing refresher training (internships), with a factor loading of 0.738; providing worthwhile maintenance training opportunities, with a factor loading of 0.725; and providing maintenance training by apprenticeships, with a factor loading of 0.718.

The p-value for KMO = 0.920 in Table XIII is greater than the 0.000 significance level, indicating that the sampling was sufficient for maintenance culture. As a result, a 0.00 significance level was used to reject Bartlett's test of sphericity. The correlation matrix cannot be a matrix of identity because the p-value is less than 0.000.

TABLE XIII KMOBT

KMOSAM		0.920
BST	AC-S	2399.373
	Df	66
	Sig.	0.000

Strong factor loadings for every variable in the maintenance culture ranged from 0.692 to 0.814, above the minimum of 0.50. Six variables out of the 12 have a higher potential to affect maintenance culture: management of maintenance resources, job planning and scheduling, preventive and corrective maintenance, backlog control and priority system adoption, work order system adoption, and performance measurement adoption.

IV. SUMMARY OF FINDINGS

The quality of maintenance was the second most important element affecting building maintenance management after the deterioration of buildings. The least important factor was the maintenance culture. Strong factor loadings (0.700-0.800) existed for each factor and impacted building maintenance management. Only a few of the 12 components (maintenance methods, culture, and management) with factor loadings ranging from 0.801 to 0.941 were found to have a significant impact. Maintenance budgeting and auditing were the remaining factors with the highest factor loadings (0.940). Building maintenance management was found to be moderately influenced by additional factors (staffing and training, maintenance strategy, maintenance performance management, maintenance management practice, maintenance information systems, quality of building maintenance, and maintenance documentation) (0.725-0.794).

V. CONCLUSION AND RECOMMENDATION

This study aims to identify suitable maintenance strategies for public buildings in the Central Region. All factors or constructs were found to have strong loadings with their respective variables. Maintenance budgeting and auditing, maintenance techniques, maintenance culture, and maintenance management were rated higher than other factors and constructs in building maintenance management. Therefore, it is recommended that building maintenance personnel in the Central Region consider the obtained factors or constructs when conducting future maintenance work. They should also involve the Development Officers of various establishments in the initial stages of maintenance work.

VI. THE IMPLICATIONS OF THE STUDY

The study reveals that organisations should practise effective maintenance management by adopting rigorous maintenance budgeting, auditing, proactive maintenance techniques and management practices, and a well-thought-through organisational culture.

VII. LIMITATIONS OF THE STUDY

Though the study provides valuable contributions, it did not consider the specific organisational uniqueness of all public institutions in generating the variables. Therefore, organisations must be careful in integrating the findings into their systems by giving thoughtful consideration to their organisational setups and operations.

REFERENCES

[1] A. A. Olanrewaju, Revealing the service gaps in building maintenance service delivery: balancing providers' perspectives with users' perspectives, *Int. J. Built Environment and Asset Management,* Vol. 1, No. 2, pp. 121-138, 2013.

[2] A. Idrus, F. Khamidi, and A. Lateef, "Value Based Maintenance Management Model for University Buildings in Malaysia," *Journal of Sustainable Development,* Vol. 2, No. 3, 2009.

[3] P. J. Cobbinah, Maintenance of buildings of public institutions in Ghana, Kumasi: *Unpublished dissertation* submitted to College of Arts and Architecture, Kwame Nkrumah University of Science and Technology, 2010.

[4] K. R. McNaught, and A. J. Saddington, "Engineering maintenance decision-making with unsupported judgement under operational constraints," *Safety Science,* Vol. 153, pp. 105756, 2022, DOI: https://doi.org/10.1016/j.ssci.2022.105756.

[5] N. S. Buys, Building maintenance management systems in South African tertiary institutions. *Unpublished PhD thesis*, University of Port Elizabeth, Port Elizabeth, 2004.

[6] R. E. Olagunju, Development of Mathematical Models for the Maintenance of Residential Buildings in Niger State. Federal University of Technology, Minna, Nigeria: *Unpublished Ph.D. Thesis,* 2011.

[7] H. Y. H. Lee, and D. Scott, "Strategic and operational factors influence on the management of building maintenance operation processes in sports and leisure facilities, in Hong Kong," *Journal of retail & leisure property,* Vol. 8, No.1, pp. 25-37, 2009b.

[8] U. Kumar, D. Galar, A. Parida, C. Stenstrom, and L. Berges, "Maintenance performance metrics: a state-of-the-art review," *Journal of Quality in Maintenance Engineering*, Vol. 19, No. 3, pp. 233-277, 2013.

[9] R. K, Singh, A. Gupta, A. Kumar, and A. T. Khan, "Ranking of barriers for effective maintenance by using TOPSIS approach," *Journal of Quality in Maintenance Engineering*, Vol. 22, No. 1, pp. 18-34, 2015.

[10] P. S. Poduval, V. R. Pramod, and V. P. Jagathy Raj, "Interpretive structural modeling (ISM) and its application in analysing factors inhibiting implementation of total productive maintenance (TPM)," *International Journal of Quality & Reliability Management*, Vol. 32, No. 3, pp. 308-331, 2015.

[11] A. Straub, "Maintenance contractors acting as service innovators, Construction Innovation: Information," *Process, Management,* Vol. 11, No. 2, pp. 179-189, 2011.

[12] M. R. Yahya, and M. Ibrahim, Strategic and Operational Factors Influence on Building Maintenance Management Operation Process in Office High Rise Buildings in Malaysia. Kuala Lumpur: *1st International Conference on Sustainable Buildings and Infrastructure*, 2010.

[13] E. Tse, *Fundamentals of Strategic Management-SAGE publications*, 2010, [Online]. Available: http://www.sagepub.com/upm-data/53794_Chapter_1.pdf (accessed on 18 June 2019).

[14] H. H. Y. Lee, and D. Scott, Overview of Maintenance Strategy, Acceptable Maintenance Standard and Resources from a Building Maintenance Operation Perspective, *Journal of Building Appraisal*, Vol. 4, No. 4, pp. 269-278, 2009a.

[15] B. Chanter, and P. Swallow, *Building Maintenance Management*, 2nd ed., Blackwell, Oxford, 2007.

[16] R. Cruzan, *Manager's guide to Preventive Building Maintenance*, The Fairmont Press, Inc, 2009.

[17] W. Wang, Delay time modelling, In: Kobbacy, K.A.H., Murthy D.N.P. (eds) *Complex Syst. Maint. Handb.* SE-14, Springer London, pp. 345-370, 2008.

[18] U. Al-Turki, "A framework for strategic planning in maintenance," *Journal of Quality in Maintenance Engineering,* Vol. 17, No. 2, pp. 150-162, 2011.

[19] R. A. Wahid, and J. Corner, "Critical success factors and problems in ISO 9000 maintenance," *International Journal of Quality & Reliability Management*, Vol. 26, No. 9, pp. 881-893, 2009.

[20] R. S. Velmurugan, and T. Dhingra, "Maintenance strategy selection and its impact in maintenance function: A conceptual framework," *International Journal of Operations & Production Management*, Vol. 35, No. 12, pp. 1622-1661, 2014.

[21] F. Riane, O. Roux, O. Basile, and P. Dehombreux, "Simulation Based Approaches for Maintenance Strategies Optimisation," In Ben-Daya, M., Duffuaa, S. O., Raouf, A., Knezevic, J. and Ait-Kadi, D. (Eds), *Handbook of Maintenance Management and Engineering XXVII*, Springer, 741, 2009.

[22] H. Lind, and H. Muyingo, "Critical reflections on the concept of maintenance," *International Journal of Strategic Property Management*, Vol. 16, No. 2, pp. 105-114, 2011.

[23] I. Alsyouf, "The role of maintenance in improving companies' productivity and profitability," *International Journal of Production Economics*, Vol. 105, No. 1, pp. 70-78, 2007.

[24] J. D. Campbell, and J. V. Reyes-Picknell, *Uptime: Strategies for Excellence in Maintenance Management,* 2nd ed., Productive Press, New York, NY, 2006.

[25] M. C. Eti, S. O. T. Ogaji, and S. D. Probert, "Development and implementation of preventive maintenance practices in Nigerian industries," *Journal on Applied Energy*, Vol. 83, No. 3, pp. 1163-1179, 2006a.

[26] M. C. Eti, S. O. T. Ogaji, and S. D. Probert, "Reducing the cost of preventive maintenance (PM) through adopting a proactive reliability-focused culture," *Journal of Applied Energy*, Vol. 83, No. 11, pp. 1235-1248, 2006b.

[27] M. C. Eti, S. O. T. Ogaji, and S. D. Probert, "Strategic maintenance management in Nigerian Industries," *Journal on Applied Energy*, Vol. 83, No. 3, pp. 211-227, 2006c.

[28] A. Garg, and S. Deshmukh, "Maintenance management: literature review and directions," *Journal of Quality in Maintenance Engineering*, Vol. 12, No. 3, pp. 205-238, 2006.

[29] A. Parida, *Performance Measurement for Maintenance (MPM): A Multi-Criteria Hierarchical Approach*, LAP LAMBERT Academic Publishing, 2009.

[30] F. F. Fonseca, Preventive property maintenance: case study – Marcelino Champagnat State School – Londrina – PR, *Specialization Monograph*, Federal University of Paraná, Curitiba, 2010.

[31] B. Ofide, R. Jimoh, and E. Achuenu, "Assessment of building maintenance management practices of higher education institutions in Niger State – Nigeria," *Journal of Design and Built Environment,* Vol. 15, No. 2, pp. 1-14, 2015.

[32] G. A. Tenório de Morais, and A. C. Jr. Lordsleem, "Building maintenance management activities in a public institution," *Engineering, Construction and Architectural Management*, Vol. 26, No. 1, pp. 85-103, 2019.

[33] A. C. Marquez, P. M. D. Leon, J. F. G. Fernandez, C. P. Marquez, and M. L. Campos, "The maintenance management framework: a practical view to maintenance management," *Journal of Quality in Maintenance Engineering*, Vol. 15, No. 2, pp. 167-178, 2009.

[34] D. Dukic, M. Trivunic, and A. S. Curcin, "Computer-aided building maintenance with 'BASEFM' program," *Journal of Automation in Construction*, Vol. 30, pp. 57-69, 2013.

[35] R. Keith Mobley, *Computer-Based Maintenance Management Systems,* In R. Keith Mobley, L. R. Higgins, and D. J. Wikoff, (Eds), *Maintenance Engineering Handbook*, 7th ed. McGraw-Hill, 2008.