A Survey of Maintenance Management Systems in Indonesia Primary School Institutions

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Abstract

Maintenance considerations are essential for school facilities in achieving educational functions. In particular, the maintenance of school facilities is crucial in maintaining the operation of all building systems and components. It is a facility in creating an effective teaching and learning process by providing an environment conducive to learning and academic success. The maintenance of facilities in schools is related to things that are considered as facilities and infrastructure as stipulated in the Regulation of the Minister of National Education no. 24 of 2007. Defines facilities as a piece of transferable learning equipment, with minimum facilities consisting of furniture, educational equipment, educational media, books, other learning resources, information and communication technology, and other equipment that every school/madrasah must own. Meanwhile, infrastructure is defined as basic facilities to carry out school/madrasah functions, with minimum infrastructure criteria consisting of land, buildings, space, electrical power installations, and services that every school/madrasah must own. The above facilities and infrastructures show the characteristics of a primary school. This study aims to identify the primary school characteristics and the maintenance management system implemented in most of the schools in the area. The survey results show that most primary schools in Jabodetabek already have a maintenance management system implemented following the preventive maintenance criteria that we set in this study.

Keywords
Maintenance Management, Indonesia Primary School, Public School

1. Introduction
School buildings have an essential function in the development and growth of education to realize equitable educational development distribution. School buildings used as educational facilities need to be managed and maintained (Mulyadi, 2019). Maintenance considerations are essential for school facilities in achieving academic functions. In particular, the maintenance of school facilities is crucial in maintaining the operation of all building systems and components. It is a facility in creating an effective teaching and learning process by providing an environment conducive to learning and academic success (Hassanain, Al-Zahrani, Abdallah, & Sayed, 2019).

Primary school is one of the institutions or educational institutions that organize various educational activities for students and involves many components. The activities and elements of education in primary schools require good management to achieve their institutional goals. Currently, in Indonesia, primary school buildings reach 170,000 (Firman and Tola, 2008). The Ministry of National Education and Culture recently reported that 182,500 classrooms were severely disturbed (Taufani and Nugroho, 2014). Several classrooms in Central Java Province were severely damaged (Utami et al., 2017). School buildings collapsed in West Jakarta in 2017 and Pasuruan, East Java, in 2019 (Liu and Arifin, 2021).

School buildings are prone to damage due to the aging of their structures. This issue usually occurs due to the lack of proper maintenance. Proper maintenance has different ways depending on the building policy, the building environment, the function of the building, and the existing condition of the building. Delays in maintenance or repairs will improve the structure and increase maintenance costs (Kwon et al., 2020). Such conditions pose a challenge for primary school agencies to implement effective maintenance management.

1.1 Objectives
This study aims to identify the various primary school maintenance systems in Indonesia that can improve the quality of education.

2. Literature Review
2.1 Primary School Facilities and Infrastructures
Educational facilities and infrastructure are essential and central resources in supporting teaching and learning activities in schools. It is necessary to improve their utilization and management so that the expected goals can be achieved. However, many schools have facilities and infrastructure that are not used according to their intended function. (Perni, 2018).

Implementing a maintenance management system in an educational institution aims to improve the efficiency and competitiveness of the organization. It is also used to identify and meet the needs of the various stakeholder groups and their expectations (Doherty, 2008 and Nurcahyo et al., 2019).

The current pattern of school management approaches is different from the previous one due to regional autonomy rules. Therefore, it is necessary to adjust the management of facilities and infrastructure to optimize the provision, utilization, maintenance, and control of educational facilities and infrastructure at each type and level of education. This concept states that schools should have the autonomy to manage their interests and facilities according to their needs and abilities. This is also aimed at improving the quality of education at all levels. (Perni, 2018).

The maintenance of facilities in schools relates to matters that are considered as facilities and infrastructure. The Regulation of the Minister of National Education No. 24 of 2007 defines facilities as a piece of transferable learning equipment. With minimum criteria of facilities consisting of furniture, educational equipment, educational media, books, and other learning resources, information and communication technology, and other equipment that every school/madrasah must own. Infrastructure is defined as an essential facility to carry out the function of schools/ madrasah. With minimum infrastructure criteria consisting of land, buildings, spaces, and power installations and services must be owned by every school/madrasah (Permen, 2007).

2.2 Preventive Maintenance
Preventive maintenance is a practical approach to improving systems' reliability and quality and their components (Rao, 1992). Meanwhile, BSI standard (2018) through BS EN 13306 defines it as a maintenance activity to assess and reduce degradation and the possibility of an item's failure. Maintenance activities before a tool/machine/component failed. In order to prevent failures, the implementation of preventive maintenance must be able to indicate when maintenance activities are carried out (Yang, 2004). Preventive maintenance is a process that involves identifying and addressing potential issues before they become critical (Eti et al., 2006).

The maintenance function of an organization is focused on achieving the optimum point at the lowest cost without affecting the safety, environmental, and human factors of the organization. An organization that can effectively manage its maintenance activities as its priority will be more advantageous in time and cost. (Nurcahyo et al., 2017).

System failures cause adverse impacts to organizations, users, and customers. This negative impact can occur in output, safety, environmental integrity, system quality, customer satisfaction, and additional repair costs (Eti et al., 2006). Therefore, the implementation of preventive maintenance is needed to replace the need for corrective maintenance. As a result, unnecessary costs such as emergency repair costs after a failure can be reduced or avoided. The capital investment required for maintenance can also be minimized (Suttell, 2006).

Preventive maintenance involves a fundamental trade-off between conflicting goals, namely to minimize total maintenance costs and to maximize the overall reliability of buildings and systems. For example, a system or component that is frequently maintained or replaced will require high maintenance costs but will provide high reliability. So, a balance between the two objectives must be reviewed and obtained to achieve the effectiveness of preventive maintenance (Au-Yong, 2014).

2.3 Characteristics of Preventive Maintenance

Characteristics in maintenance management must be considered as shown in Table 1 because they tend to affect the overall maintenance performance. Effective maintenance management always strives to implement these characteristics (Au Yong, 2014). From some literature, we identified seven characteristics of maintenance management used in this study

Table 1. Characteristics of Maintenance Management

No.	Characteristic	Descriptions	Reference
1.	Maintenance policy	The proper maintenance and safety policies of an organization are vital to achieving operational excellence. These policies help optimize the use of resources and ensure that the equipment and processes are operating efficiently.	Tsarouhas (2020), Ferreira & Souza (2021)
2.	Resource management	The effectiveness of a maintenance program will be influenced by the skills and capabilities of the maintenance personnel. This will affect the poor performance of the program.	Au Yong et al. (2014), Batuna & Azizoglu (2009), Tsarouhas (2020), Fatoni et al (2018)
3.	Treatment time interval	A preventive maintenance program is carried out at fixed intervals to minimize the risk of future failures. It involves creating and optimizing components and systems to achieve minimal maintenance.	Al Turki et al. (2014), Au Yong et al. (2014), Chua et al. (2018), Batuna & Azizoglu (2009), Tsarouhas (2011), Ahmad (2017), Tsarouhas (2020), Miniati et al. (2012), Saleh et al. (2015), Wan et al. (2017)
4.	Monitoring and inspection	Monitoring is an activity that is intended to measure the physical state of an item at predetermined intervals. It is typically carried out under various operating conditions. The characteristics of an item are evaluated during various stages of its life cycle.	Bendaya et al. (2009), Al Turki et al. (2014), Au Yong et al. (2014), Chua et al. (2018), Batuna & Azizoglu (2009), Tsarouhas (2011), Ahmad (2017), Tsarouhas (2020), Miniati et al. (2012), Saleh et al. (2015), Wan et al. (2017)
5.	Maintenance equipment and techniques	Thorough maintenance is a process that involves keeping equipment and tools running smoothly. It is a process that can help prevent accidents and minimize downtime. Aside from using the proper equipment and procedures, it also helps preserve the productivity of the work.	Au Yong et al. (2014), Batuna & Azizoglu (2009)
6.	Spare parts and materials	Proper management of materials and spare parts is an essential aspect of maintenance. It can help to minimize costs while ensuring the quality of the finished products.	Bendaya et al. (2009), Al Turki et al. (2014), Au Yong et al. (2014), Chua et al. (2018), Batuna & Azizoglu (2009), Tsarouhas (2011), Ahmad (2017), Tsarouhas (2020), Miniati et al. (2012), Saleh et al. (2015), Wan et al. (2017)

7.	Financial aspect	Knowing the reliability of a system is essential in predicting the costs of unplanned downtime and parts. This technique helps identify the conditions of a system and the best time to perform maintenance.	Tsarouhas (2020), Lavy et al. (2009)

3. Method

This study uses a qualitative method to collect data from 32 primary school samples in Indonesia. It is focused on studying the perceptions of students in Bogor, Tangerang, and Jakarta. The questionnaire was addressed to teachers and employees within the scope of the school who have interactions with maintenance activities.

4. Result and Discussion

Respondents from 32 primary schools in Jabodetabek (Jakarta, Bogor, Depok, Tangerang/South Tangerang, and Bekasi) filled out the survey. Most respondents came from the Tangerang/South Tangerang area (10 primary schools), followed by Jakarta (8 primary schools), Bekasi (6 primary schools), Depok (4 primary schools), and Bogor (4 primary schools). The respondent's distribution is summarized in Table 2.

Table 2. Survey Respondents

City	Number of respondents
Jakarta	8
Bogor	4
Depok	4
Tangerang/South Tangerang	10
Bekasi	6
Total	32

The survey results are shown in Table 3 below.

Table 3. Survey Results

Preventive Maintenance Characteristic	Sub-characteristic	Responses				
		Very Appropriate	Appropriate	Neutral	Inappropriate	Very Inappropriate
Maintenance policy	System policy has been established	37,5%	59,4%	3,1%	0%	0%
	Involvement of top managements	56,3%	43,8%	0%	0%	0%
	Periodic maintenance report	25%	62,5%	12,5%	0%	0%
Resource management	Qualified maintenance personnel	21,9%	68,8%	6,3%	3,1%	0%
	Adequate number of maintenance personnel	18,8%	62,5%	15,6%	3,1%	0%
	Involvement of all parties	34,4%	62,5%	3,1%	0%	0%

Preventive Maintenance Characteristic	Sub-characteristic	Responses				
		Very Appropriate	Appropriate	Neutral	Inappropriate	Very Inappropriate
Treatment time interval	Maintenance time interval has been set	18,8%	62,5%	15,6%	3,1%	0%
	Maintenance plan priorities	15,6%	78,1%	3,1%	3,1%	0%
Monitoring and inspection	Maintenance schedule has been set	18,8%	71,9%	6,3%	3,1%	0%
	Periodically priority maintenance	28,1%	65,6%	6,3%	0%	0%
	Documented maintenance	15,6%	78,1%	3,1%	3,1%	0%
Maintenance equipment and techniques	Facilities/ Infrastructure in good condition	31,3%	62,5%	6,3%	0%	0%
	Maintenance guide has been set	15,6%	68,8%	12,5%	3,1%	0%
Spare parts and materials	Sufficient number of components / spare part	6,3%	68,8%	18,8%	6,3%	0%
	Quality of components / parts	6,3%	62,5%	25%	6,3%	0%
Financial aspect	Budget has been set	25%	65,6%	6,3%	3,1%	0%

4.1 Maintenance Policy

The majority of the respondents thought that the school's facilities management system was appropriate. Most schools have a maintenance system that is designed to keep the facilities running smoothly. This system is usually implemented through the involvement of the top management team; as many as 56.3% of respondents stated that it was very appropriate, that shown in Table 3. Top management plays an essential role in expressing the vision, mission, and various values through its policies and significantly influences maintenance culture (Eti, Ogaji, and Probert, 2006). Some of the teachers questioned the implementation of the maintenance policy in the school. They noted that they did not understand the provisions of the policy.

4.2 Resource management

Most schools already have a maintenance workforce both in terms of qualifications and numbers. Effective maintenance management can be achieved because errors and errors that occur during maintenance work can be reduced if maintenance personnel in the school have sufficient numbers, skills, and knowledge. The allocation and coordination of resources, including personnel, can improve maintenance performance in maintenance management systems. In addition to the function of maintenance personnel, the maintenance management system can be implemented with the involvement of all teachers, employees, students, maintenance, and building users (Chua et al., 2018).

4.3 Treatment time interval

Table 3 shows that most schools also already have a predetermined maintenance time interval and priorities. Márquez (2007) said that scheduling for specific maintenance tasks needs to be done with enough time to schedule and supply any resources, including the schedule on a priority condition. It aims to ensure that many important and urgent activities are carried out first with efficient resources. The maintenance time interval is adjusted to critical functions

linked to the company business goals, should be following equipment failure and critical goals; that in assessing critical aspects can wildly differ such as maintenance direct and indirect cost, availability, and reliability. According to Márquez (2007), preparing priorities is based on the preparation of critical criteria.

4.4 Monitoring and inspection

Table 3 shows that most schools also already have schedules, periodic and documented maintenance. The maintenance program or plan needs to be prepared and executed according to the maintenance policy. The plan or program needs to be specific and detailed to accomplish the assigned tasks and responsibilities. The inspection report is required in all existing buildings to check their conservation status. It can identify and map the various pathologies that may affect the building's structural integrity. It also contains recommendations for various maintenance techniques on a building. These recommendations are usually implemented in phases and require a certain amount of time to be fulfilled (Ferreira & Souza, 2021).

4.5 Maintenance equipment and techniques

The facilities and infrastructure of most schools are in good condition. Good facilities and infrastructure create an effective teaching and learning process by providing an environment conducive to learning and academic success (Hassanain, Al-Zahrani, Abdallah & Sayed, 2019). In preventive maintenance, parts of the building system must be replaced at regular intervals to ensure the system's continuous operation. Availability of equipment and technical maintenance is needed for preventive maintenance because it can impact maintenance. Poor management can result in delays in maintenance or procurement of equipment that costs more than usual. Thus, adequate equipment must be considered to ensure that the required or maintenance tasks are timely.

4.6 Spare parts and materials

No less critical in the maintenance of school facilities and infrastructure is the components / spare parts of the facility. Most schools have components / spare parts with good quality and numbers. The type of scheduled maintenance must pay attention to acquiring material, spare parts from external sources, or available inventory and support equipment (Márquez, 2007). Performance can be maintained if the equipment has no problems with the availability of parts and materials. However, if the budget is low, the lack of funds can procure substandard materials and components that can cause expensive repairs. (Chua, 2018).

4.7 Financial aspect

Table 3 shows that out of the 32 primary schools surveyed, 65.6% have a maintenance budget plan. A maintenance budget allocation is a crucial component of a comprehensive maintenance program to ensure acceptable building conditions. Regular maintenance is essential to ensure the proper operation of the facilities. It is only possible if the funds allocated for it are sufficient and are used to organize human resources and other resources. The maintenance managers must present solid and well-documented arguments to be granted higher priority in the institution's overall budget plans (Buys et al., 2006).

5. Conclusion

In response to the several preventive maintenance questions, most primary schools in Jabodetabek have such a scheme. This characteristic is a critical factor in the maintenance system that can significantly improve the performance of facilities and infrastructure in schools. This paper recommends that top management of schools pay attention to these characteristics when planning and implementing maintenance so that maintenance and effectiveness of activities can be improved and achieved. Good facilities and infrastructure condition is the responsibility of all parties in the school. A good coordination and communication platform is recommended to involve all teachers, employees, students, maintenance personnel, and building users in planning and implementation maintenance in schools. Schools must have a long-term plan to meet the changing conditions of their facilities. Long-term planning is an integral part of school operations. It needs to be updated regularly to keep up with changing conditions of the facilities in the surrounding environment adapting to regional autonomy policies. This condition has a direct impact on the teaching and learning process, it is very important for schools to provide a healthy learning experience for quality education. (Au-Yong et al., 2014).

References

Ahmad, Rosmaini, Reliability Analysis Comparison on Punching Tool Sets Due to Different Maintenance Decisions: a Case Study from The Pulp Manufacturing Industry, Int J Adv Manufacturing Technology, 2017.

Al-Turki, U.M., Ayar, T., Yilbas, B.S., and Sahin, A.Z., Integrated Maintenance Planning in Manufacturing Systems. Springer, 2014.

Au-Yong, C.P., Ali, A.S., and Ahmad, F., Preventive Maintenance Characteristics towards Optimal Maintenance Performance: A Case Study of Office Buildings, World Journal of Engineering and Technology, 2014, 2, 1-6, 2014.

Batun, S. and Azizoglu, M., Single Machine Scheduling with Preventive Maintenance, International Journal of Production Research, Vol. 47, No. 7, 1753–1771, 2009.

Ben-Daya, M., Duffuaa, S.O., Raouf, A., Knezevic, J., Ait-Kadi, D., Handbook of Maintenance Management Engineering. Springer, 2009.

BSI Standards, Maintenance-Maintenance terminology, The Bristish Standard Institution, 2018.

Buys, F., & Nkado, R. A survey of maintenance management systems in South African tertiary educational institutions. *Construction Management and Economics*, *24* (10), 997–1005. https://doi.org/10.1080/01446190600851009, 2006.

Chua, S.J.L., Zubbir, N.B., Ali, A.S., Au-Yong, C.P., Maintenance of High-Rise Residential Buildings. International Journal of Building Pathology and Adaptation, Vol. 36 No. 2, pp. 137-151, 2018.

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. http://dx.doi.org/10.1016/j.apenergy.2006.01.001, 2006.

Fatoni, Z. Z. Z., & Nurcahyo, R., Impact of training on maintenance performance effectiveness, *Proceedings of the International Conference on Industrial Engineering and Operations Management*, *2018*(JUL), 619-628, 2018.

Ferreira, F. M. C., & Souza, H. A. D., Management for maintenance of public education, *Gestão & Produção*, *28*(1). https://doi.org/10.1590/1806-9649.2020v28e4894, 2021

Firman, H.; Tola, B., The Future of Schooling in Indonesia. J. Int. Coop. Educ. 2008, 11, 71–84.

Hassanain, M. A., Al-Zahrani, M., Abdallah, A., & Sayed, A. M., Assessment of factors affecting maintenance cost of public-school facilities, *International Journal of Building Pathology and Adaptation*, *37*(5), 528–546. https://doi.org/10.1108/ijbpa-02-2019-0019, 2019.

Lavy, S., & Bilbo, D. L., Facilities maintenance management practices in large public schools, Texas. *Facilities*, *27*(1/2), 5–20. https://doi.org/10.1108/02632770910923054, 2009.

Liu, S.-S., & Arifin, M. F. A. Preventive Maintenance Model for National School Buildings in Indonesia Using a Constraint Programming Approach. Sustainability, 13(4), 1874. doi:10.3390/su13041874, 2021.

Márquez, C. A. The Maintenance Management Framework Models and Methods for Complex Systems Maintenance, Springer Series in Reliability Engineering ISBN 978-1-84628-821-0, 2007.

Miniati, R. Dori, F.,Gentili,G.B., Design of a Decision Support System for Preventive Maintenance Planning in Health Structures. Technology and Health Care 20 (2012) 205–214 DOI 10.3233/THC-2012-0670, 2012.

Mulyadi, B., Prosedur Penentuan Prioritas Pemeliharaan Gedung Sekolah Menengah Atas Negeri di Kabupaten Balangan. Jurnal Teknologi Berkelanjutan, 8 (1), pp. 19-23, 2019.

Nurcahyo, R., Arisaputra, A. E., & Farizal., Development of maintenance program with Markov-Simulation method in aviation industry, *2017 4th IEEE International Conference on Engineering Technologies and Applied Sciences (ICETAS)*, Published, https://doi.org/10.1109/icetas.2017.8277888, 2017.

Nurcahyo, R., Meiliana, A., Zulfadlillah, & Habiburrahman, M., The comparison of student satisfaction between certified and non-certified ISO 9001 schools. *Proceedings of the International Conference on Industrial Engineering and Operations Management*, (November), 130-138, 2019.

Perni, Ni Nyoman, Tantangan dalam Manajemen Sekolah Dasar. Jurnal Pendidikan Dasar Volume 3, Nomor 1 April 2018, 2018.

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

Saleh, N., Sharawi, A., Elwahed, M.A., Petti, A. Puppato, D., Balestra, G., Preventive Maintenance Prioritization Index of Medical Equipment Using Quality Function Deployment. IEEE Journal of Biomedical and Health Informatics, 2015.

Suttell, R., Preventive HVAC Maintenance Is a Good Investment. In The Source for Facilities Decision-Makers: Buildings, UNICCO Integrated Facilities Services, Newton, 2006.

Taufani, A.R.; Nugroho, A.S.B. Proposed bamboo school buildings for elementary schools in Indonesia. Procedia Eng, 95, 5–14, 2014.

Tsarouhas, P.H., Reliability, Availability and Maintainability (RAM) Study of an Ice Cream Industry. Applied Science, 10, 4265, doi:10.3390/app10124265, 2020.

Tsarouhas, P.H., A Comparative Study of Performance Evaluation Based on Field Failure Data for Food Production Lines, Journal of Quality in Maintenance Engineering, 17 (1), pp. 26-39, 2011.
Utami, T.D.; Chernovita, H.P.; Fibriani, C. Analysis of Primary School Infrastructure Damage using Simple Additive Weighting Method and Map Visualization. Ilm. Tek. Inf. 2017, 6, 66–73.
Wan, J., Tang, S., Li, Di, Wang, S., Liu, Chengliang, L., Abbas, H. Vasilakos, A.V., A Manufacturing Big Data Solution for Active Preventive Maintenance, IEEE Transactions on Industrial Informatics, 2017.

Biography / Biographies

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