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Assessing Delay Factors and Mitigation Measures in Building Maintenance Works

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Abstract: When it comes to the operation of a construction industry, building maintenance is critical. Any structure must be well-maintained to prevent minor problems from becoming major ones. Delayed building maintenance may result in increased repair costs as well as a reduction in building lifespan. To avoid this problem, research has been conducted to identify the factors that cause building maintenance delays and mitigation measures to resolve building maintenance delays. To achieve the study's objectives, extensive literature research and a questionnaire survey were conducted. Based on previous literature research, accumulated data was used to create a questionnaire for 250 Malaysian building maintenance delay factors and mitigation measures. A group of professionals and experts, including top management, project managers, engineers, architects, assistant engineers, technicians, human resources and administration, and others, participated in this survey. SPSS statistical software was used to analyse the collected data using the average mean index method and correlation. According to the data, the three highest mean index values from the factors that cause maintenance work delays are *an increase in maintenance costs as the building age increases, an incorrect timing for work can incur higher maintenance costs when a critical job item is overlooked, and improper planning and budgeting*. For correlation analysis, it was found that the correlations amongst the five groups of delay factors are having strong relationship with Pearson correlation value of 0.5. While for mitigation measures of the delay, it was found that three highest ranks are *prefer other organizational structure* follows by *policy and objective* and *good communication*. The findings can assist construction practitioners in prioritising their maintenance works.

Keywords: Building maintenance, delayed maintenance, construction

1. Introduction

Malaysia government is concerned on building aspect especially regarding the delay of building maintenance. The typical understanding and approaches need changes to suit the current scenarios and requirements in the concept of building maintenance in Malaysia even though the concept has already existed ever since modern buildings were constructed (Ademeyi, 2005). Building maintenance management is also a highly complex sphere of operations, involving the interaction between the technical, social, legal, and financial determinants which govern the use of buildings. Operational management of public buildings is always needed. Poor operational management, especially in building maintenance, can affect building quality and comfort (Putri et al., 2020). The condition and quality of the buildings are one of the most fundamental components of the quality of life. Combinations of technical and

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administrative actions in building maintenance are the basic standard to ensure the items and elements of a building are at an acceptable standard to perform their required function. A proper building maintenance plan and monitoring systems are necessarily needed to implement building maintenance tasks effectively (Ajanlekoko, 1987). This study focused on factors that cause a delay in maintenance work for buildings in Malaysia.

Work carried out in anticipation of failure is referred to as corrective maintenance. Corrective maintenance involves repairs and upgrades to restore an asset to full power and optimal condition (Escano, 2022). It is a well-known fact that the primary objective of building maintenance is to preserve buildings in their initial functional, structural, and aesthetic states (Francis et al., 2001). This is to ensure that such a facility continues to remain in such a state and retains its investment value over a long period of existence. Buildings are generally required to provide a safe and conducive environment for the performance of various human activities. The ability of a building to provide the required environment for a particular activity is a measure of its functionality (Khalid et al., 2006). Building users expect to be comfortable and safe also unaffected by building damage (Triwijayanty et al., 2020). Therefore, as the components of a building begin to deteriorate, it becomes necessary to take measures to ensure that the desired characteristics of that facility which provides safety and convenience are retained.

2. Delay in Building Maintenance

The performance of the construction industry in terms of time was poor (Odediran et al., 2012). They emphasized that timely delivery of projects within budget and to the level of the quality standard specified by the client is an index of successful project delivery. Delays are unacceptable since they will lead to significant losses, including low productivity (Gunawan, 2021). Failure to complete work during a targeted time, budgeted cost, and specified quality results in various unexpected negative effects on the projects. Normally, when the projects are delayed, they are either extended or accelerated and therefore, incur an additional cost. If the upkeep of a building is not adequately managed, it will typically result in buildings that are, in the long run, extremely costly to buy or operate (Olanrewaju et al., 2022). The project manager must continuously and effectively plan, control, and monitor the project over its entire life cycle to ensure that it stays on track (Rahman, 2018). Therefore, delays in construction projects give rise to dissatisfaction among the parties involved and the main role of the project manager is to make sure that the projects are completed within the budgeted time and cost.

2.1 Factors Causing Delays in Building Maintenance

Generally, maintenance factors can be divided into two main factors, which are technical factors and administration factors. In terms of technical factors, some aspects that affect the maintenance of buildings are poor workmanship, poor quality of materials and spare parts. While in terms of administration factors, the aspects that influence maintenance in the building include poor maintenance at the right time and poor budgetary control (Yasin et al., 2018). The great majority of flaws in building projects are the result of human mistakes means that a human error occurred because of poor performance in the workmanship involved in the building's construction (Alsen et al., 2020). The selection of the maintenance management team and staff are closely related to the selection of maintenance factors that affect the delays in building maintenance. Table 1 below is the summary of the main factors that have been determined from the literature review.

Table 1 - Factors causing delays in building maintenance

Factors	Description
Organization	Poor maintenance management -Poor maintenance management practices are neither cost-effective nor optimum, and often cause a lot of problems, such as defective buildings, poor building functionality and others Poor management of the maintenance team. -The absence of such management and leading people, will lead to time-consuming and most likely failed maintenance works
Time	Failure to execute maintenance at the right time Failure or delay to execute maintenance actions at the right time may cause further implications to incur such as excessive damage, wear and defect

Table 1 - Factors causing delays in building maintenance (Cont'd)

Factors	Description
Cost	Budget constraints -The asset or building failure rate increases as time pass and this produces most repair and maintenance tasks

	The increasing maintenance cost is needed while the building age is growing older Poor budgetary control -Quality of maintenance activities are influenced by the amount of budget allocation in each task
Workmanship	Poor workmanship is the predominant cause of defects emerging on the projects or maintenance works Owing to poor workmanship, more defects will occur immediately or after the period, the maintenance works are done The total maintenance costs are likely to be increased because of poor workmanship during the implementation of maintenance works Poor or lack of training. Maintenance personnel training is one of the reasons for poor operating practices in maintenance management
Infrastructure and Technology	Poor quality of spare parts and materials used in the building components, elements, services, or facilities significantly influence the maintenance costs The problems related to the lack or unavailability of the required spare parts, tools, or materials to perform maintenance tasks Lack of maintenance software tool. There is no renewing or upgrading of the old system available which will require more maintenance

2.2 Consequences of Delay in Building Maintenance

The consequences of failing to maintain the building at the appropriate time can be divided into three categories:

i. Disruption to property use and structural consequences
ii. Increased costs
iii. Unexpected liabilities

The component's deterioration rate and the corresponding increase in the cost of rectification are likely without an early response to such a defect. Early response to building failure is necessary to reduce major defects and at the same time reduce maintenance costs. However, an early response to the building defect or failure cannot be done if there is a delay and failures in reporting the problems. Delay and failure in reporting problems do affect the building maintenance cost to some extent, but the significance of this factor is not that obvious.

Maintenance and operating expenses are the major components of housing costs for building maintenance. Maintenance and operating expenses contribute one-third to one-half of the total cost depending on the type of housing such as condominium, apartment, flat and others. This also impacts the owner's pocketbook. Continuous building maintenance is important since buildings degrade over time due to natural causes such as climate, daily occupant use, mechanical ageing, and others. When these issues stay unsolved, they can degrade user experiences, create dangerous and unhealthy conditions, and even incur costs that are bigger than regular building maintenance costs (Cao, 2020).

Understanding the importance of maintenance to building owners and the public, in general, is vital (Yasin et al., 2017). Owners of the building must be aware of the necessity of maintenance works, so they can plan, budget, and finance the work of maintenance to keep their facilities in acceptable condition and to avoid future breaks down and failures that will result in loss of money and time (Yasin et al., 2019). Facility owners should realize that they should maintain their facilities periodically and not leave their equipment in the state of emergency breakdown maintenance, which will cost them much more than if they use planned maintenance (Yasin et al., 2015). These expose the owners to increased risks of damage and legal action. Table 2 below is the list of consequences of delayed maintenance by following its categories.

Table 2 - Consequences of delay in building maintenance

Categories	Description
Disruption to the property use and structural consequences	Increased outages associated with power supply, gas, and other utilities Disruption of essential services such as increased downtime of elevators or heat Structural damage Collateral damage to finishes and substrates from water leaks Accelerated deterioration of some assets requiring earlier renewal and unforeseen costs. Increased costs due to lack of coordinated planning, crisis response accumulation of deferred maintenance, unnecessary repairs, and shortened service lives

	More unexpected changes during project implementation because of rushing design packages
Increased costs	Greater financial hardship through unexpected special levies Increased insurance deductibles due to a failure to mitigate The lower resale value of the property Potential for fines and penalties due to non-compliant condition(s)
	Potential for accidents and injuries to owners and guests due to unsafe slip, trip, and fall conditions
Unexpected liabilities	The effect of warranties due to failure to meet a duty of care Failure to approve repairs resulting in court actions

3. Methodology

This study adopted a quantitative research approach. The data was collected through questionnaire survey amongst a group of building maintenance practitioners in Malaysia using structured questionnaire (Yasin et al., 2019). The questionnaire was developed based on the objectives of this study and was given out to the selected respondents using simple random technique of distribution (Yasin et al., 2018). In total, 250 respondents had participated in this questionnaire survey. The data was analysed by using Statistical Packages for Social Science (SPSS, Version 22) to generate the required results.

4. Ranking Analysis

Ranking analysis is a technique for determining the significance or ranking of items in a list or set. There are numerous approaches to ranking analysis, and the specific approach will depend on the analysis's goals and the type of data being analysed. The process of evaluating and analysing the rankings of a set of items or entities based on specific criteria is commonly referred to as ranking analysis. This can be done in a variety of contexts, such as analysing website rankings in search engine results, evaluating the performance of sports teams in a league, or evaluating the quality of academic institutions based on various metrics. Depending on the situation, a variety of techniques and tools can be used to conduct ranking analysis. Some common methods include (Yasin et al., 2018):

i. Data visualization: Using charts, graphs, and other visual aids to display and compare ranking data.
ii. Statistical analysis: Using statistical methods to identify trends, patterns, and correlations in ranking data.
iii. Machine learning: Using algorithms and models to predict future rankings based on historical data.
iv. Expert judgment: Using the opinions and insights of subject matter experts to evaluate and interpret ranking data.

Overall, ranking analysis can provide useful insights into the relative performance and quality of various entities, and it can be used to inform decision-making in a variety of fields. However, in this study, the delay factors in building maintenance were ranked from highest to lowest using a mean index. It used Statistical Package for Social Science (SPSS) to analyse the collected data which provide the value of a mean index.

4.1 Ranking of Delay Factors in Building Maintenance

According to Figure 1 below, the factors that cause a delay in building maintenance work for the building are discovered. From the table, the highest mean index obtained is 4.008, which the maintenance cost increases while the building age increases. This is due to the element of the structure that has exceeded the lifespan limit, it will give an additional cost rather than a new building. It is followed by inaccurate timing for work and can incur higher maintenance costs when a critical job item has been overlooked 3.948. This factor is due to the unprepared job procedure plus the work increases when the work was not done in the right situation leading to the cost of maintenance work increasing when the work needs to be done twice. Next are the improper planning and budget, which is 3.940. This means the preparation work before the maintenance work was not carried out sufficiently, this can cause extra costs for maintenance work including services work. For the middle rank, most of the construction labour are immigrants, which leads to a lack of understanding and miscommunication 3.856. From this factor, it shows that communication problems take place which can cause wrong interpretation of instruction. It is then followed by poor workmanship and skills with 3.832. This is because the laborers have limited skills in maintenance; hence the work done will give unsatisfactory work results. Next, the maintenance budgeting processes do not refer to budgeting purposes with a mean index of 3.828. During the tender process, the budget for maintenance work is not referring to the real budget purposes, but it follows the existing budget from the previous one which can lead to an insufficient budget, or the budget provided for maintenance work is limited.

For the lower ranking, the mean index of 3.552 is the maintenance department has poor communication. Workers and even engineers are not informed about the department's goals, objectives, and plan. This is because the department did not realize the importance of updating the information and work procedure for the workers. This can lead to the productivity of the department drop. It is then followed by an unclear job description and department structure with 3.472.

Due to this factor, the work done is unsatisfactory and workers did not get the full information and instruction for the work that needs to be done. The instruction given from the top management to the bottom level of the organization must be clear and in detail to ensure that the workers will follow the flow of work. Lastly, the lowest rank is policy, and the objective of the maintenance is not stated clearly with a mean index of 3.412. This means that all maintenance work that needs to be done must follow the policy and the objective of the department.

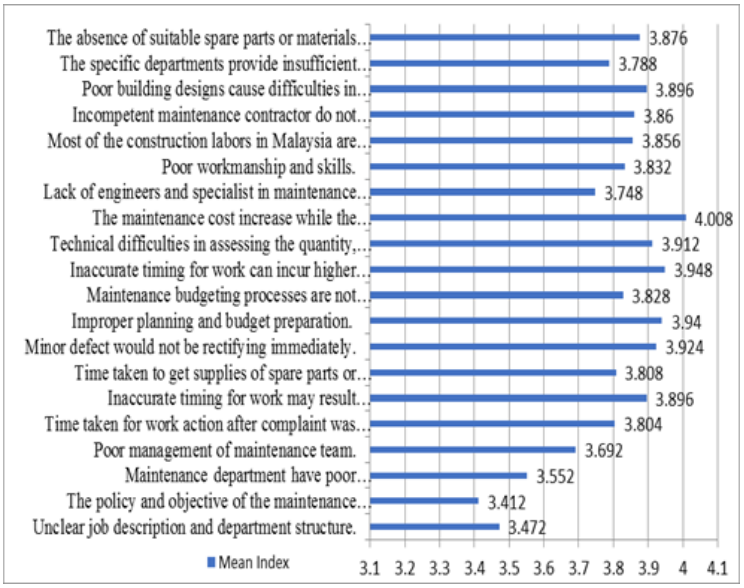

Fig. 1 - Mean index of factors causing delays in building maintenance

The correlation coefficient used to predict the value of data can be influenced by changes in other data, which means identifying the linear relationship between two variables (Fachinger et al., 2004). To perform the correlation analysis, two steps need to proceed. The first is to compute all the 40 elements in 5 different groups. Once it has been computed, select the 54 items, and proceed to the correlation analysis.

Table 3 - Correlations of causing factors in building maintenance delay

Correlations						
		Organization	**Time**	**Cost and Budget**	**Workmanship**	**Infra and Technology**
Organization	Pearson Correlation	1	.479**	.416**	.321**	.235**
	Sig (2- tailed)		.000	.000	.000	.000
	N	250	250	250	250	250
Time	Pearson Correlation	.479**	1	.597**	.371**	.234**
	Sig (2- tailed)	.000		.000	.000	.000
	N	250	250	250	250	250
Cost	Pearson Correlation	.416**	.597**	1	.445**	.313**
	Sig (2- tailed)	.000	.000		.000	.000
	N	250	250	250	250	250
Workmanship	Pearson Correlation	.321**	.371**	.445**	1	.398**
	Sig (2- tailed)	.000	.000	.000		.000
	N	250	250	250	250	250
Infra and Technology	Pearson Correlation	.235**	.234**	.313**	.398**	1

	Sig (2- tailed)	.000	.000	.000	.000	
	N	250	250	250	250	250

**correlation is significant at the 0.01 level (2- tailed)

The result of the correlation analysis from Table 3 was produced from the software of SPSS by using the Pearson method. This result shows the linear relationship between the five variables. Moreover, the figure also shows the significance level between the variables. The significant level obtained from all the variables was less than 0.05, which indicates that there is a significant correlation between the variables. Therefore, the analysis can proceed. As the value is nearer to 1 is considered a strong relationship between the variables. Thus, the highest value obtained is 0.597 showing it was a strong relationship between time and cost variables. This can be concluded that time will directly influence the cost and budget for maintenance.

It was then followed by the organization and time for maintenance work 0.479. It shows that the organizational structure has affected and a gives impact on completion work completion if the management is not well organized. Next, the cost and budget with workmanship are 0.445, which means limited cost and budget will lead to poor workmanship with skills and expertise for this maintenance work.

The lowest value obtained from the Pearson correlation analysis was the relationship between time and infrastructure and technology with 0.234. This shows that the factor of infrastructure and technology had slightly affected by the factor of time comparable to the relationship with other variables. However, the overall value of the Pearson correlation analysis acquires was high, which is more than 0.5, indicating that there was a strong relationship between these variables.

4.2 Ranking of Delay Mitigation Measures in Building Maintenance

Based on the result obtained from the SPSS statistic software in Figure 2, shows that the mean index for every element is the best solution. Therefore, it can be used to become the solution to overcome the problem that causes a delay in maintenance work. The highest value for the mean index obtained was to prefer other organizational structures having mean score of 4.460. This means that the structure of the organization is controlled by having a systematic system of management and the workers were satisfied with their current structure, which is a functional structure. The next mean index value is followed by policy and objective to ease the process of maintenance work having mean score of 4.384.

Policies and objectives need to be clear to achieve the goals that have been planned at the initial stage. Next, the mean index value selected for good communication between parties needs to be implemented correctly during all work processes having mean score of 4.332.

In the middle rank of the mean index value, ranked no. 10 is preparing the maintenance budget that needs to be planned efficiently at the initial stage of the work to keep all the necessary maintenance work performed with 4.248 mean index values. It is then followed by completing the work given on time with a mean index value of 4.244. Inspection by the expert will ensure that the maintenance work has been done satisfactorily. The next mean index value is by using a system to control the cost with 4.240. This means that by using an established system the cost of maintenance work can be controlled to avoid exceeding the budget.

Based on the survey, the lower rank obtained was the design of the building stated clearly with the value of the mean index of 4.116. Sustainable design needs to be considered in the early stages of construction to avoid excessive spending, especially on the project cost. It is then followed by software tools for maintenance with a mean index value of 4.068. Recording all the past maintenance work and data in systematic systems such as computerizing it into software that is related to the maintenance system will smoothers the maintenance work. Lastly, the lowest mean index obtained from this survey is 2.092, which uses local materials and spare parts. This shows that using local materials will reduce the cost of maintenance work. Thus, materials can also easily be found.

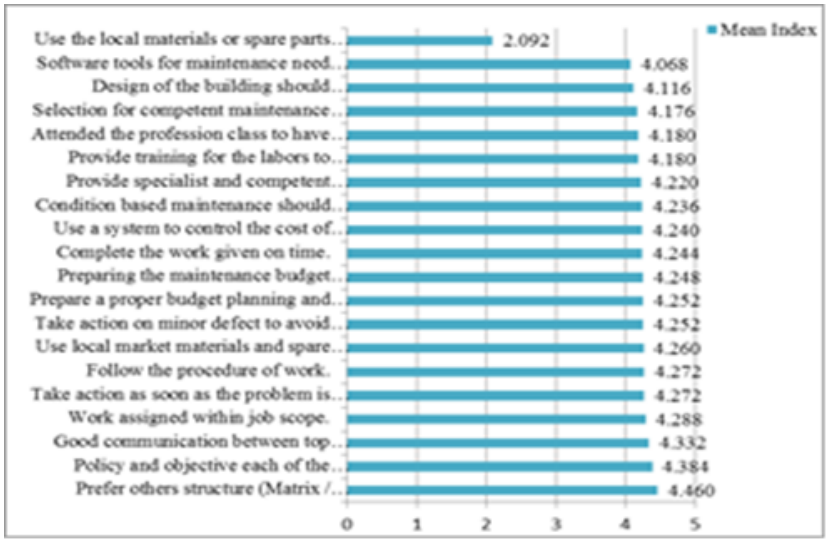

Fig. 2 - Mean index of the solution of delay in building maintenance

5. Conclusion

This paper has discussed a study on assessing the delay factor and its mitigation measure on the building maintenance works. The study was conducted through questionnaire survey using structured questionnaire among the building practitioners in Malaysia construction industry. The respondents were requested to rate each of the factors and the mitigations measure using 5-points Likert scale. The data collected from the survey was analysed statistically using the SPSS software. After the analysis, it can be concluded that the main factor of delay in maintenance problems is the maintenance cost increase while the building age is increasing, an inaccurate timing for work can incur high maintenance costs when a critical job has been overlooked and lastly improper planning and budget. Based on the problems faced caused by delays in maintenance work, it can be sure that the cost and budget are the main issues toward the problem. Moreover, the solutions for the problem of delay in maintenance work are using a system to control the cost of work maintenance, using local materials or spare parts for buildings to ease the process of maintenance work, and following the procedure of work can help to reduce the work delay in maintenance work of building.

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