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Optimising Maintenance Cost by Prioritising Maintenance of Facilities Services in Residential Buildings

Abstract

Purpose – The paper illustrates the maintenance prioritising for facilities services in high-rise residential buildings in Peninsular Malaysia. Maintenance prioritisation is becoming more prominent in the building maintenance industry due to budget constraints, poor maintenance management and to yield better maintenance performance.

Design/methodology/approach – Two main categories with eleven facilities services that require maintenance were identified through extensive literature review. A total of 321 returned questionnaires were analysed to distinguish the relationship between the maintenance priority and cost variance. Semi-structured interviews were then conducted to validate the findings.

Findings – The findings revealed that five essential facilities services were significantly correlated to cost variance and a prediction model which examines the probability of over-budget was developed. Meanwhile, the interviews recognised that maintenance prioritisation has impact towards maintenance cost.

Research limitations/implications – This research focuses on the maintenance priorities of facilities services and their effects to maintenance cost. However, it is undeniable that the maintenance cost can be affected by other factors, contributing to a lower percentage of the total variance in the prediction model. Thus, it creates research opportunity to study the factors (i.e. manpower, materials, wear and tear, etc.) affecting the variance of maintenance cost.

Practical implications – This study is useful to property managers in efforts to enhance the cost performance via appropriate maintenance prioritisation. The essential facilities services should be highly prioritised compared to the value-added facilities services.

Originality/value – The paper signifies the importance of maintenance prioritisation. It serves as a guide to plan and execute maintenance planning in a more logical way within budget and time constraints.

Keywords: maintenance priority, facilities services, residential, high-rise building, building maintenance, maintenance cost

1. Introduction

Shelter is an essential need for human well-being. As sustainability continues to be a critical concern in the construction industry, it demands residential buildings to be constructed in a higher quality, accessibility, energy efficiency, and provide facilities that promote active and social activities in a clean and safe residential environment (Winston, 2010). As a result of increasing demand for housing and the shortage of land for development, high-rise residential building developments growing rapidly, particularly in major town areas in Malaysia such as Klang Valley, Penang and Johor Bahru (Mohd Thas Thaker & Chandra Sakaran, 2016).

Indeed, all the buildings and their facilities are necessary to be maintained for the purpose of effective operation in good condition (Abd-Wahab et al., 2015). When housing stocks increase drastically, the question on their maintenance arises. In Malaysia, it is claimed that construction industry stakeholders are good at providing state-of-the-art buildings and facilities but lack of knowledge and expertise to maintain the building stock (Kamaruzzaman & Zawawi, 2010). Poor maintenance of buildings can lead to accidents, injuries and other tragedies (Lee, 2017). Therefore, the maintenance of buildings is critical and on demand to address the challenge to restore and repair the building (Arukesamy, 2017; Au-Yong et al., 2017).

However, the importance of building maintenance in the domestic housing industry in Malaysia has been neglected (Tiun, 2009; Yusof et al., 2012). Most of the time, minimum budget is allocated to preserve the quality of the residential building. As a result, some residential buildings have not evidenced any substantial maintenance or shown slight progress of maintenance since the builder left the site (Talib et al., 2014). Whereby, the maintenance is only carried out when failure occurs, which is usually repair or replace work. In fact, corrective maintenance is not an appropriate practice and it might imply negative towards the residents, building and even environment (Mat Nah et al., 2015).

1.1 Maintenance Cost in High-Rise Residential building

According to Tan (2011), the maintenance fund of high-rise residential buildings is collected from the owners or residents. The amount charged is calculated by dividing the total operating and maintenance cost with the total units built in the residential building project. He mentioned that effective maintenance of the residential building subjects to the adequate collection of maintenance fee from the owners and residents.

Unfortunately, there are many disputes and issues occurring in relation to the collection and management of maintenance funds throughout the time (Abd Wahab et al., 2017). Subsequently, it leads to poor implementation of maintenance. Insufficient maintenance funding is always the main problem in residential building management due to poor collection of maintenance fee from owners and tenants (Zairul et al., 2015). Several arguments of the residents who refused to pay the maintenance fee are recorded as follows (Abd Wahab et al., 2017):

- The imposed amount of maintenance fee is not parallel with the provision of facilities at the property (Abd-Wahab et al., 2015; Tawil et al., 2012).
- The imposed amount of maintenance fee is not compatible with the delivery of service quality (Tawil et al., 2012; Tiun, 2009).
- Lack of transparency in managing the maintenance fund expenses by the management (Tawil et al., 2012).

Taking into cognisance the issue of limited maintenance funds, Chong et al. (2016) proposed maintenance prioritisation as a solution by weighting criticality of the maintenance tasks and prioritising them accordingly. Nevertheless, the success of the maintenance prioritisation cannot be guaranteed without proper planning, specifically when time and cost are critical concerns (Edward et al., 1998; Eti et al., 2006; Irigaray & Gilabert, 2009; Wu et al., 2006). The current maintenance prioritisation effort is not effective and may lead to poor resource allocation, as it relies on the subjective evaluation based on the experience and knowledge of the maintenance manager (Chong et al., 2016). Therefore, this paper examines the relationship between maintenance priority towards facilities services of high-rise residential buildings, and their associated maintenance cost.

2. Maintenance Priority

Management of maintenance priority is the allocation of resources or preference setting to the maintenance tasks (Chong et al., 2016). Due to time or budget constraints, maintenance prioritisation is introduced, where it secures the maintenance fund for the tasks with higher priority. Shen (1997) mentioned a developed guideline for determining the maintenance priorities as follows in descending order:

a) Essential tasks to safeguard the resident safety (e.g. building structures).
b) Fundamental tasks to ensure property is liveable (e.g. aspects of hygiene, security, electrical, and water supply).

c) Significant tasks to retain buildings in an operable condition (e.g. vertical transportation system and telecommunication system).
d) Basic tasks to maintain the property's physical appearance, facilities or non-essential services (e.g. swimming pool and landscaping).

Prioritising the maintenance tasks of facilities services is vital. Commonly, the maintenance actions are prioritised by taking into consideration the cost and risk factors, which seek to maximise the maintenance performance and minimise the risk of failure (Sharp & Jones, 2012). Velmurugan and Dhingra (2015) state that the priorities of maintenance work orders contributing to the effective implementation of maintenance strategy. Sometimes, maintenance priorities are compulsory when it involves the corrective maintenance for severe facilities (Ismail, 2014). Hence, several factors are taken into consideration in the decision-making of maintenance prioritisation as follows (Chong et al., 2016):

- Risk – related to safety, health and comfort
- Performance measurement – benchmarking, post-occupancy evaluation, key performance indicators
- Resources – available budget, equipment, labour, and time
- Stakeholders – management committee, owners, residents, and tenants

Consequently, maintenance priorities assist the maintenance personnel and building owner to carry out maintenance tasks according to critical levels and subsequently achieve user satisfaction at optimal cost (Sharp & Jones, 2012).

3. Building Facilities Services that Require Maintenance Prioritisation

Buildings decay under various conditions, which include deterioration, climate change and ageing process. Taking into cognisance the heavy usage and stress in high-rise residential buildings due to high occupancy rates, maintenance is crucial to retain the buildings throughout the building life cycle in an acceptable condition (Hui, 2005) to retain the value of the property and maximise the return on investment (Tiun, 2009). In fact, execution of maintenance works is essential to secure the habitability of the property and operability of buildings (Yusof et al., 2012). Whereby, the availability of facilities services such as power supply, water supply, lifts, security and fire services system are essential (Mohit et al., 2010). The design and construction of high-rise residential buildings are becoming even more sophisticated which demand for better maintenance management to meet the needs of building users and the building can be operable in an optimum condition. In fact, a study from Tucker and Masuri (2018) concludes the decisions about facilities services are most impactful in the project management of building projects during stage 0 "Strategic Definition" and stage 4 "Technical Design" of the RIBA Plan of Work.

Besides that, building maintenance has implications towards building safety. The safety of the building occupants highly rely on the maintenance of fire services systems and security systems. However, the major issues faced by residential buildings are poor management and maintenance of fire safety systems which endanger the safety of the building occupants (Yau et al., 2008). Thus, Yusof et al. (2012) claimed that maintenance of building is crucial to provide a safe and healthy environment to residents.

Maintaining all the buildings' systems simultaneously may involve massive costs, which the housing committees and owners will definitely not be able to afford. Therefore, maintenance prioritisation plays a vital role to enhance the building condition, property values and providing

a safe and healthy environment at reasonable cost (Velmurugan & Dhingra, 2015). Based on an extensive literature review, the facilities services in high-rise residential buildings that require maintenance prioritisation are as shown in Table 1.

Table 1: Facilities services that require maintenance prioritisation

Facilities services in a residential context are generally considered as services that support the ability for building users to suitably and safely reside in residential building. These facilities services can be 'hard' in nature where they are directly integrated into the buildings infrastructure (e.g. lifts, utilities, fire) or can be 'soft' in nature where they are directly delivered by human activity (e.g. cleaning, social facilities, and security).

For the purpose of this study, the services in Table 1 are divided into two categories, namely 'essential' facilities services and 'value-added' facilities services. The essential facilities services deal with the well-being, health, liveable and operability of buildings that are mandatory in residential buildings (Chiang et al., 2015; Hui, 2005; Lai & Yik, 2011; Mohit et al., 2010; Yau et al., 2008; Yusof et al., 2012); while value-added facilities services deal with property value, return on investment, and addition features that are optional in residential buildings (Chiang et al., 2015; Hui, 2005; Lai & Yik, 2011; Tiun, 2009).

4. Maintenance Performance – Cost Variance

The measurement of performance is often cited as a critical aspect of building maintenance (Tucker et al., 2014). The measurement of performance always emphasises the level of achievement or catastrophe of three perspectives, namely time, cost and quality (Johnson, 1995; Sidwell, 1990). Somehow, the building maintenance performance is frequently measured in the aspect of cost. Maintenance cost variance is calculated using variance of actual cost and planned cost for building maintenance activities (Ali, 2009). The amount of difference between actual and planned cost determine the level of maintenance performance where the maintenance performance is considered good if total cost is less than proposed budget and vice versa.

Knowing that the limited maintenance fund as one of the main concerns by the industry and public (Zairul et al., 2015), the research utilises the maintenance cost variance as the dependent variable. By identifying the research variables, a theoretical framework is formulated as shown in Figure 1. The theoretical framework shows the relationship between the maintenance priority towards building facilities services, and the maintenance cost variance. The findings and result of this research will be able the respond the argument of Tam and Price (2008), stating that there is no research about the maintenance prioritisation quantifying the expenditure of maintenance works.

Figure 1: Maintenance priority of the facilities services towards the maintenance cost performance

5. Research Method

This research uses a mixed method approach, as adopted in Au-Yong et al. (2014). The approach involves an extensive literature review, questionnaire survey and semi-structured interviews. This method enable researchers to deal with more complicated research questions and achieve higher reliability and validity of the research (Yin, 2009). Generally, the research was distributed into phases and implemented in sequence.

Firstly, the building facilities services that require maintenance were identified by searching and reviewing relevant literature. Then, a closed-ended questionnaire survey was drafted using a five-point Likert scale and multiple choice questions (MCQ's) based on the outcomes of literature review. Overall, the questionnaire included three parts; the respondent's details, maintenance priority towards the facilities services (measured via the level of priority from scale of 1 to 5), and maintenance cost variance (measured via the ratio of actual maintenance expenditure to planned maintenance expenditure).

In the questionnaire survey, a simple random sampling method was applied to determine the potential respondents that have involved or are presently managing high-rise residential buildings. This approach provided higher accuracy of the sample selection randomly which incorporates all essential criteria in the population (Saris & Gallhofer, 2007). Population criteria encompassed building criteria, which were high-rise residential buildings (7 floors and above) situated in Peninsular Malaysia. Currently, there were 1902 schemes of high-rise residential buildings in Peninsular Malaysia (NAPIC, 2016) which was set as the research population. In order to ensure the random sampling process, a postal questionnaire survey was conducted by sending out the questionnaire to all schemes under the research population with follow up call. Nevertheless, the number of returned questionnaires was not sufficient. Then, personal-administered questionnaire was done by visiting the management offices of the high-rise residential buildings to seek response from the relevant personnel. Subsequently, 321 sets of valid questionnaires were collected. Whereby Krejcie and Morgan (1970) computed that the minimal sample size for a research population of 1900 is 320.

The respondents were maintenance personnel involved in high-rise residential buildings, including property managers, property executives or supervisors, building technicians, and other building management staff. 63 percent of the respondents were property managers, building supervisors and executives who expert in planning and execution of housing maintenance management undertakings (refer Figure 2). Meanwhile, 62 percent of the respondents had more than 5 years of working experience in the housing maintenance management industry (refer Figure 3). Based on the background and position of the respondents, the gathered information was noticeably reliable and accurate.

Figure 2: Respondents' profile

Figure 3: Respondents' working experience

In the data analysis stage, a reliability analysis test, namely Cronbach's alpha coefficient test, was executed for the maintenance priority of facilities services to verify the reliability of data. This exploration was performed in order to check the consistency of the scale of data via Statistical Package for Social Science (SPSS) (Leech et al., 2011). The test result indicated a coefficient of 0.894 for the maintenance priority of facilities services. Whereby, a coefficient of 0.70 and above shows good reliability.

In order to accomplish the research aim, data analysis methods of Au-Yong et al. (2014) were referred to. A correlation analysis was run to assess the association between the maintenance priority of facilities services and maintenance cost variance. When the measurement of scale for the data are ordinal, Spearman rank-order correlation is appropriate for the analysis (Graziano & Raulin, 2010).

Further verification of the relationship was done by using binary logistic regression. It produced the regression model of maintenance cost variance (probability of over-budget). Typically, logistic regression equation is as follows:

$$\boldsymbol{Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k + \varepsilon} \quad (1)$$

Where,
Z = latent variable
$X_1, X_2, ... , X_k$ = independent variables
β_0 = constant
$\beta_1, \beta_2, ... , \beta_k$ = change in Y for a change of one unit in $X_1, X_2, ... , X_k$ respectively
ε = error term

Z value is inserted into a link formula to find the likelihood of the event taking place. In this circumstance, the link formula to compute the likelihood of over-budget in maintenance activities is stated below:

$$\mathbf{P\ [over\text{-}budget]} = \boldsymbol{e^z/1+e^z} \quad (2)$$

With the purpose of corroborating the results obtained from the questionnaire survey and analysis, property managers with experience in housing maintenance management of five years or more were set as the criteria for interviewees. The questionnaire respondents who fulfilled the requirements were shortlisted as potential interviewees. Semi-structured interviews were performed to collect additional information about the maintenance priority of facilities services towards maintenance cost variance. For instance, an interview question was "*Does maintenance priority towards lift systems significantly influence the maintenance cost variance? How does it influence the cost variance?*" The interview enables the investigator to discover and reveal the interviewees' opinions exhaustively (Marshall & Rossman, 2006).

80 respondents were filtered as fulfilling the interviewee's criteria, nonetheless, only 10 of them accepted to take part in the interview due to the work restriction. The responses given by the interviewees reached a saturation after 6 participants were interviewed, where the replies provided by the interviewees were alike and expectable deprived of new input (Ali, 2008). Even so, the interview was executed with every accepted participant. Distinct from the questionnaire survey, the participants were asked to provide detailed explanation of maintenance priority towards maintenance cost variance.

6. Findings and Discussion

The 11 independent variables of facilities services were analysed using correlation analysis. The analysis result was tabulated in Table 2. Whereby, higher maintenance priority towards the facilities services is probably to reduce the maintenance cost variance. Negative association between the maintenance priorities and cost variance was anticipated in the analysis result. Statistically, a coefficient of below 0.3 shows a weak association; a coefficient of 0.3 to 0.5 specifies a moderate association; and a correlation coefficient of 0.5 and above reflects a strong association between two variables (Gray & Kinnear, 2012; Saunders et al., 2009). Moreover, SPSS demonstrates significantly associated variables with the significance value of 0.05 or below. Among 11 independent variables, 5 of them are significantly correlated to the cost variance, namely:

(a) Lift systems
(b) Water supply systems
(c) Power supply systems

(d) Security systems
(e) Fire protection systems

Table 2: Correlation between maintenance priority towards building facilities services and maintenance cost variance (n = 321)

The findings revealed that the maintenance priority of lift systems is significantly associated to maintenance cost variance, with a coefficient of -0.408 ($p < 0.05$). It supported the views of Vyas and Munz (2013), who argued that low maintenance priority on lift systems would implicate the need of repairs and thus causing much higher cost over the budget. The components of lift systems are expensive. Therefore, high maintenance priority is essential to minimise the components failure that lead to costly repair or replacement. One of the interviewees highlighted the importance of lift maintenance and said that:

> "…we should prioritise maintenance of lift systems and allocate sufficient funds for it, so that unwanted costly service or repairs can be avoided. Sometimes, breakdown of lifts may happen contagiously and it will affect residents' safety."

Meanwhile, the Spearman's rank correlation test detected significant correlation between the maintenance priority of water supply systems and maintenance cost variance, with a coefficient of -0.148 ($p < 0.05$). The result supported that proactive maintenance towards water supply systems could minimise the ad hoc maintenance expenditure and operational interruption efficiently (Park et al., 2015). Hydraulic systems like water pumps should be inspected and maintained regularly to avoid unwanted failure that is costly to repair. One interviewee stated that:

> "…maintenance priority on water supply systems is important, especially the water pump, because failure of water pumps might require extensive repair and impose higher cost."

The analysis result then demonstrated that maintenance priority of power supply systems is significantly correlated to maintenance cost variance, where $r = -0.178$ ($p < 0.05$). The statement by Meng (2013) was verified, which noted that timely inspection and maintenance of power supply systems such as wiring could possibly reduce the system failure that would cost three times higher for repair and replacement works. Thus, the maintenance of power supply systems should be prioritised by allocating competent technicians to carry out regular inspections. One of the interviewees further elaborated the impact of power supply issue:

> "…some cases of power supply failure caused further damage to the electrical appliances. In the end, the power supply system itself has to be repaired, yet the damaged appliances have to be replaced. This is really a nightmare, where a lot of money would be spent."

According to the correlation result, the maintenance priority of security systems is significantly correlated to maintenance cost variance, with coefficient of -0.295 ($p < 0.05$). Indeed, there are various types of security systems like CCTV systems, access card systems, and barrier gate systems. The maintenance of all these systems should be prioritised to secure the safety of building residents and assets. Whereby, maintenance of the systems should be conducted periodically as they are having normal degradation process (Caballé et al., 2015). Maroof et al. (2016) demonstrated that installation and maintenance of security devices positively contribute to the safety of residents and property. An example was quoted by an interviewee:

> "…security systems are one of the most emphasised facilities by the residents nowadays. Usually, several types of security systems are provided in a condominium like barrier gates, access card systems, CCTV systems and others. Most of the systems need to be checked regularly to prevent failure and unplanned repair cost. By having a well-functioning security system like CCTV, vandalism cases are reduced. Indirectly, the management gets rid of the unwanted maintenance cost caused by vandalism."

Another important facility service that requires maintenance prioritisation is the fire protection system. It is significantly correlated to maintenance cost variance, where $r = -0.173$ ($p < 0.05$). Xin and Huang (2013) mentioned that regular inspection and maintenance of firefighting systems installed in the building is the key to ensure its performance and reliability. Poorly maintained systems would not function in the event of fire. Subsequently, building damages would incur more maintenance and repair expenditure. One interviewee argued that:

> "…there is no way for you to ignore the maintenance of fire protection systems, as it is governed by the fire department (BOMBA). You can be penalised if maintenance of fire protection system is not performed as stipulated in the regulation."

In order to verify the association test result and to further recognise the significant predictors of the maintenance cost variance, logistic regression analysis was run including the eleven independent variables as the predictors. The analysis only takes in all the significant predictors (with significant values of less than 0.05) and omits all the insignificant predictors (with significant values of more than 0.05) from the regression model. In the analysis, maintenance cost variance was coded into a dichotomous scale with values of 0 and 1. Whereby, "not over-budget" and "over-budget" were labelled as 0 and 1 respectively.

Table 3: Variables in the equation

By applying the forward stepwise method, SPSS developed a step (refer Table 3) to take in the predictor that significantly contributed to the prediction model. Step 1 indicated the maintenance priority of lift systems significantly forecasting the probability of maintenance cost variance with $X^2 = 33.73$, $p < .05$. Thus, there is only one independent variable significantly predicting whether or not the over-budget of maintenance cost occurs. In this case, 16.0% of the variance in maintenance cost could be predicted from the maintenance priority of lift systems (LS). Then, the p-value for Hosmer-Lemeshow goodness of fit was 0.200 (> 0.05). Thus, the model adequately fit the data. Then, the following prediction equation was produced (refer to Table 3):

$$\boldsymbol{Z = 2.887 - 1.101\ LS}$$

The scale of the predictor was enumerated from 1 to 5 and represented "very low priority" to "very high priority" respectively. Then, the scale could be placed in the formula in order to find the likelihood of maintenance cost variance. Hence, the maintenance priority of lift systems is the significant factor that is influencing the probability of maintenance cost variance. A high level of maintenance priority towards the system is expected to increase the probability of maintenance expenditure within budget.

6.1 Recommendations

Since maintenance prioritisation is proven to have an impact towards maintenance cost performance, practice of maintenance prioritisation is recommended in the maintenance of high-rise residential buildings. The maintenance prioritisation was discussed in the interview

sessions. The interview respondents were all of the opinion that the essential facilities services should be top-prioritised as they ensure the daily activities of the residents run smoothly. This corroborates with the statistical analysis findings that identified five essential facilities services as being most significant; namely lift systems, water supply systems, power supply systems, security systems and fire protection systems. It is therefore recommended that adequate budget planning and allocation must be given to these essential facilities services.

It is clear that these essential facilities services tend to be more 'hard' in nature and it is recommended that property managers are fully equipped and experienced with dealing with such facilities services. Due to the nature of these hard services, they are more risk intensive, and often carry greater health and safety requirements, which are often governed by stricter standards and regulations. A critical recommendation therefore is for property managers to carefully consider the service specialists contracted to deliver them. Typical factors such as the length of contract, service level agreement (SLA), and maintenance strategies to be deployed. Subsequently, proper implementation of the maintenance tasks can be secured without interruption due to shortage of maintenance funds. On the other hand, a lesser maintenance priority can be set to the value-added facilities services when funds are limited.

Further research on the maintenance of each facilities service (maintenance criticality, expected maintenance resources, maintenance strategies, maintenance schedules, procurement methods, related regulations, etc.) are proposed so that the implementation of maintenance prioritisation can be more efficient.

7. Conclusion

The literature review suggests that a well-planned maintenance strategy based on rational assessment of priorities will ensure better performance and optimise the available resources. The literature further emphasises that the ever-increasing maintenance needs and backlogs for residential buildings, especially high-rise residential buildings, which provide essential and value-added facilities services need to be prioritised to safeguard a habitable and safe living environment for their residents.

The findings of this research highlighted five essential facilities services; namely lift systems, water supply systems, power supply systems, security systems and fire protection systems which need to be prioritised when planning maintenance task. All these facilities services have been acknowledged and validated as fundamental for buildings to be operable in an acceptable condition. In addition, through the development of a prediction model, emphasised that lift systems are the most significant factor which are likely to increase the probability of maintenance expenditure within the given budget.

It was proven that prioritisation in maintenance plays a vital role in ensuring the building is operable and liveable as well as optimising the available resources. The findings of the research can serve as a guide for property managers to plan and execute maintenance planning in a more logical way within budget and time constraint.

Acknowledgement

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