BUILDING MAINTENANCE ACHIEVEMENT IN HIGH RISE COMMERCIAL BUILDING: A STUDY IN KLANG VALLEY, MALAYSIA

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Abstract: The value of buildings depends on the achievement of the maintenance invested in them. Building maintenance management engages getting maximum benefit from the investment made on the maintenance activities. Building maintenance in high rise commercial buildings in Malaysia is on the increase regardless of size, type, location, and ownership. This paper aims to develop a maintenance achievement index (MAI) to benchmark the performance of building maintenance from a number of key performance indicators (KPIs). Eleven high rise office buildings were investigated through randomly selection in Klang Valley, Malaysia. The research collected 110 respondents from in-house building maintenance personnel and outsourced consultant as well as contractors with managing and operating building maintenance activities experience of high rise commercial buildings through unstructured interviews. In addition, a maintenance achievement equation was formulated from the primary components analysis to generate a multiple score so as to show the level of achievement of building maintenance management. The findings of study had shown that building maintenance practitioners believe quality, safety, time, cost, functionality, and environmental friendliness can be considered as KPIs for building maintenance activities. A single index can also be computed from the maintenance achievement equation to apply different weightings to the respective KPI with different significance such that the performance of building maintenance managements can be compared. The idea of achievement remains unclear among building maintenance practitioners, which makes it complicated to measure whether the performance of a building maintenance management is accomplishment or failure. This research establishes the need to develop a MAI which can be a tool in order to measure and value on the whole performance of the building maintenance activities and compute the success model in a scientific approach in order to ensure the consistency of quality, safety, time, cost, functionality, and environmental friendliness to building stakeholders all the time.

Keywords: Building Maintenance; Maintenance Achievement Index

INTRODUCTION

The maintenance necessities are relatively challenging. It is significant to have a well-developed building maintenance management to ensure the high rise commercial building in good circumstance. At present building stakeholders are more concerned about building maintenance achievement and its performance since their expectancy is usually high as it reflects the buildings image as well as competitive return in terms of a marketing approach to attract more people to buy and rent.

There are several aspects in the building maintenance management such quality, safety, time, cost, functionality as well as environmental friendliness are very important to building owner, tenants, customers, users and maintenance professionals in order to ensure that they are in comfort and safety

zone all the time and get the benefits. Understanding and implementing the six aspects are necessary for the management of building maintenance operation for high rise commercial buildings.

Lee and Scott (2008) identified building maintenance achievement as the main aspects influencing the operation and maintenance activities. It also controls progress of work and monitoring building maintenance budget expenditure. In this connection, maintenance personnel responsibility are needed for the maintenance operation in order to build up key performance indicators for monitoring building maintenance management operation processes.

It is important to ensure stakeholders and end-users understand the benchmarks and satisfy with all building maintenance performance for operational processes enhancement. Benchmarks are established for building maintenance management describing the process improvement with consistent policies and procedures, frequent communication, managing maintenance resources, problem solving and attempts to remove barriers, prompt handling of customer feedback and continuous improvement. Benchmarking is defined by construction best practice programme (CBPP) as a efficient method of comparing and assessing the performance of the building maintenance management, and using lessons learned from the best to make targeted improvements (Takim and Akintoye, 2002).

According to Lee , H . et al (2008), building performance can be an indicator of building maintenance achievement in all related aspects of operation and maintenance activities. Nutt (2004) found that building maintenance performance as an indicator in order to sustain the operation and strategy level in an organization within its functions. Moreover, according to Amaratunga and Baldry (2002), building maintenance personnel should concern about building maintenance achievement performance in order to sustain building performance that contributes to business as well as its image. Facility effectiveness, cleanliness standard, indoor air quality, energy efficiency, lighting standard, thermal comfort, safety and information technology are several factors related to building performance.

According to Ko and Cheng (2007), the traditional measurements of management success in the construction industry are, namely, schedule (time), cost, performance (quality) and safety. While not many studies identify KPIs for building maintenance management, there exists some consensus among previous researchers on the traditionally accepted indicators for assessing the performance of building maintenance management in six aspects including:

Quality

Bubshait and Almohawis (1994) defined quality as the degree and service standards to which the general conditions promote meeting of the management achievement of materials and workmanship. It is also expressed in terms of technical specification, function and appearance. Moreover, according to Shohet (2003), quality dealings with the response time in order to execute work requests together with the time taken to return plant and equipment to service.

Safety

Bubshait and Almohawis (1994) defined health and safety as the degree to which the general conditions in management without major accidents of injuries. This was supported by Love and Edwards (2004), who considered that safety is a significant factor that contributes to management performance, and thus must never be compromised.

Time

Bubshait and Almohawis (1994) defined time as the degree to which the general conditions promote the completion of tasks given within the allocated duration. Naoum (1994) and Chan (1996) measured this criterion by time overrun and operation time respectively. In fact, the timing of major jobs may not always depend entirely on the physical condition of the element, but also on funding availability (Al-Zubaidi, 1997).

Cost

Bubshait and Almohawis (1994) defined cost as the degree to which the general conditions promote the completion of a task within the estimated budget. It was measured by Naoum (1994) and Chan (1996) as cost overrun and unit cost respectively. While Al-Zubaidi (1997) classified the cost of maintenance work into long-term, medium-term and short-term estimates, Yik and Lai (2005) further classified the major cost elements into the costs of human resources, energy, consumables and spare parts.

Functionality

The requirements of technical performance are normally established in specifications and its performance is best measured by the degree of variations from those listed in specifications. Shohet (2002) also claimed that functionality is an important measure for building maintenance activities.

Environmental friendliness

Sherwin (2000) found out that the latest additional objective for maintenance is to endorse environmental sustainability and so modern maintenance management systems now generally

include provision for safety and environmental legal requirements.

The benchmarking exercise involves setting up a number of KPIs to measure performance of building maintenance management. There is correlation between building maintenance achievement and performance management which can be used as indicator of improvement on building maintenance performance.

PROBLEM STATEMENT

A lower standard of quality, safety, time, cost, functionality as well as environmental friendliness in operational and maintenance activities seem to be the ordinary insufficiency in building maintenance management (El-Haram and Horner, 2002; Tse, 2002; Shen, 1997). Madu (2000) found that lack of coordination and implementation of building maintenance achievement, goals as well as contradiction to organizational direction can cause common problems and deficiencies in the building operation processes.

According to Chan *et al* (2001), operations and maintenance activities in high rise building are more complex, which leads to higher maintenance cost. There is a connection between improving maintenance effectiveness and the management approaches, the stakeholders' aspect to achieve the effectiveness of maintenance performance. Chan *et al* (2001) discovered that maintenance activities are not obvious and are always unseen clearly by the management.

Furthermore, there are numerous condemnations, particularly, inability and below standard of building maintenance is closely linked to the inadequate financial resources (Hui, 2005).

Shen (1997) observed that maintenance personnel focused just on technical aspects and lack of understanding on strategic and building maintenance achievement or performance aspects. Hence they are lack of inputs in their decision-making which reflects to the requirements of building maintenance management and its occupants as well as end-users. As a result, these complications put in to below standard of building maintenance performance.

AIM OF RESEARCH

This paper aims to develop a maintenance achievement index (MAI) to benchmark the performance of building maintenance from a number of key performance indicators (KPIs), using a basic assessment method since quality, safety, time, cost, functionality as well as environmental friendliness are among the most challenging aspects in the high rise commercial buildings. Six aspects were chosen as research focus because they are the most fundamental aspects that building maintenance management should achieve and yet they usually cannot be easily observed and evaluated by building owners, occupants and end-users. Moreover, maintenance problems have a stronger spill over effect in a high-density setting than a low-density one a building with poor management not only adversely affects its occupants, but also jeopardizes those occupying and working in the building. The research, therefore, contributes to the revelation of hidden building information to the occupant as well as parties who related to operation and maintenance activities in order to improve more sustainable building maintenance performance.

RESEARCH METHODOLOGY

Eleven high rise office buildings were investigated through randomly selection in Klang Valley, Malaysia. The research collected 110 respondents from in-house building maintenance personnel and outsourced consultant as well as contractors with managing and operating building maintenance activities experience of high rise office buildings through unstructured interviews. In addition, a maintenance achievement equation was formulated from the primary components analysis to generate a multiple score so as to show the level of achievement of building maintenance management.

A set of questionnaire was prepared to request in-house building maintenance personnel and outsourced consultant as well as contractors for their personal views on the success criteria for building maintenance tasks or activities based on quality, safety, time, cost, functionality as well as environmental friendliness aspects.

The respondents were asked to rate each attribute for the construct of the KPIs for building maintenance activities on a five-point Likert scale to indicate the level of importance, ranging from "1" equal to "Highly unimportant" to "5" equal to "Highly important". The data were input into SAS for statistical analysis to compute a maintenance achievement index (MAI) for building maintenance activities.

Principal components analysis is a technique for forming new variables that are linear composites of the original variables (Sharma, 1996). It is concerned with explaining the variance-covariance structure of a set of variables through a few linear combinations of these variables (Johnson and Wichern, 2002). The technique can be applied to compositional data, which consists of observations $x_1, x_2, \ldots, x_n$, for which each element of x_i is a proportion, and the elements of x_i are constrained by the sum of the unity (Jolliffe, 2002). Assuming that there are p variables,

the use of the principal components analysis gives the following *p* linear combinations.

$$\xi_1 = w_8 x_1 + w_9 x_2 + \ldots + w_{1p} x_p$$

$$\xi_2 = w_{10} x_1 + w_{11} x_2 + \ldots + w_{2p} x_p \ldots$$

$$\xi_p = w_{p1} x_1 + w_{p2} x_2 + \ldots + w_{pp} x_p$$

where $\xi_1, \xi_2, \ldots, \xi_p$ are the *p* principal components and w_{ij} is the weight of the *j*th variable for the *i*th principal component. The first principal component, ξ_1, accounts for the maximum variance in the data. Moreover, this relationship is expressed as:

$$w^2_{i1} + w^2_{i2} + \ldots + w^2_{ip} = 1;\ i = 1, \ldots, p$$

Sharma (1996) believed that the principal components analysis is an appropriate technique for developing an index. The variables are called "formative indicators" of the components as the index is formed by the variables. In the equation of the MAI for building maintenance activities, the sum of the squares of the weights of the KPIs is equal to one and the variances of the principal components are the Eigenvalues of the matrix (Manly, 1986). According to Kaiser's rule, any principal components with a variance less than 1 are not worth retaining and the first principal component, ξ_1, accounts for the maximum variance in the data (Jolliffe, 2002).

RESULTS AND DISCUSSIONS

Building maintenance expects with managing and operating building maintenance activities or tasks experience perceived that the successful of building maintenance activities can be measured by quality, safety, time, cost, functionality as well as environmental friendliness aspects which were identified as the variables to form the principal components scores. The results of the SAS analysis are summarized in Table 1.

The eigenvalue-greater-than-one rule states that only those variables whose eigenvalues are greater than one are retained; as a result, only the first order was retained. From the results of the principal components analysis, the eigenvectors give the weightings that are used in forming the following equation for MAI:

MAI = 0:397 Time + 0:452 Cost + 0:327 Quality + 0:281 Functionality + 0:398 Safety + 0:541 Environmental friendliness and the sum of the squared weights of each principal component is one, i.e. $0.397^2 + 0.452^2 + 0.327^2 + 0.281^2 + 0.398^2 + 0.541^2 = 1$

The equation, MAI, enables building maintenance expects to understand the performance of their building maintenance activities in a more scientific way. Once the equation is developed, the scores on each criterion of time, cost, quality, functionality, safety and environmental friendliness can be input by the building maintenance expects to generate the MAI for their building maintenance activities to indicate the overall level of building maintenance performance. Table 2 demonstrates the loadings and coefficients of the identified KPIs in the equation for MAI.

In fact, the higher the loading of a variable, the more influential the variable is in forming the MAI for building maintenance activities. Moreover, the magnitudes of the coefficients agree with those of the loadings. Therefore, the strengths of the KPIs affecting the overall success of a building maintenance activity can be represented by their corresponding coefficients. Environmental friendliness, cost and safety were shown to be the more important indicators of success by the empirical study of the building maintenance expects as well as by previous researchers. In fact, the proper handling of waste and pollutants when managing maintenance activities is considered important from social and legal points of view. Moreover, activities involving demolition and renovation require closer attention on safety than functionality issues. Therefore, the performance of environmental friendliness and safety of a building maintenance activity can significantly affect its overall success level as represented by the MAI.

Assessing performance for building maintenance activities

The performance of building maintenance activities can be compared with the use of MAI. In order to apply MAI to actual practice, the respondents were asked to rate each attribute for the construct of satisfaction with performance on a five-point Likert scale to indicate how well their projects performed from their perspectives, and the score for each KPI was entered into the equation developed from the current study.

The MAI score provides an indicator for comparing the success level of building maintenance activities and sets a benchmark for quantifying the successful performance of a building maintenance activity. While the performance of building maintenance activities can be measured objectively in terms of hard data, the perceptions of building maintenance expects on the level of success of their building maintenance performance can be quantified by the MAI. Table 3 presents the MAI scores of 11 building maintenance managements in high rise commercial buildings located in Klang Valley, Malaysia.

Table 1: Principal components analysis of KPIs for building maintenance activities

Order	Item	KPIs	Eigenvectors	Eigenvalues
1st	A	Time	0.397	1.197
	B	Cost	0.452	
	C	Quality	0.327	
	D	Functionality	0.281	
	E	Safety	0.398	
	F	Environmental friendliness	0.541	
2nd	A	Time	-0.436	0.608
	B	Cost	-0.636	
	C	Quality	0.179	
	D	Functionality	0.360	
	E	Safety	0.098	
	F	Environmental friendliness	0.484	
3rd	A	Time	0.205	0.462
	B	Cost	-0.004	
	C	Quality	0.391	
	D	Functionality	0.652	
	E	Safety	-0.509	
	F	Environmental friendliness	-0.348	
4th	A	Time	0.443	0.343
	B	Cost	-0.424	
	C	Quality	-0.269	
	D	Functionality	0.271	
	E	Safety	0.580	
	F	Environmental friendliness	-0.348	

Table 2: Loadings and coefficients of KPIs in MAI equation

KPIs	Time	Cost	Quality	Functionality	Safety	Environmental friendliness
Loadings	0.397	0.452	0.327	0.281	0.398	0.541
Coefficients	0.605	0.631	0.586	0.449	0.620	0.734

Table 3: MAI scores for 11 building maintenance managements in high rise commercial building located in Klang Valley, Malaysia

Building Maintenance Management	MAI
1	8.76
2	6.34
3	11.58
4	9.58
5	8.86
6	7.87
7	8.32
8	7.19
9	7.84
10	9.89
11	9.58

The respondents assessed the performance of their building maintenance activities based on time, cost, quality, functionality, safety and environmental friendliness out of their subjective judgement, and the MAI scores were calculated using the equation developed in the study. A score of "1" was given to each of the six identified KPIs in the equation if the respondent was not at all satisfied with the performance of the building maintenance management. Consequently, the smallest possible value of the MAI is 2.396 (in the event that each KPI is given a score of "1") while the largest possible value is 11.98 (in the event that each KPI is given a score of "5"). Therefore, Building Maintenance Management 3 was the most successful as it has the highest MAI score of 11.58 while Building Maintenance Management 2 scored the lowest (MAI = 6.34) among the pool of building maintenance managements in high rise commercial buildings.

CONCLUDING REMARKS

Maintaining existing building activities has been put as the top agenda item of most building maintenance managements in their maintenance planning. While maintenance achievement is an abstract concept, the identification of key performance indicators enables building maintenance performance to be improved and the quantification of the perceptions towards success even sets a benchmark for maintenance excellence. This paper provides a review of success criteria for building maintenance managements with a view to developing a framework of key performance indicators (KPIs) for building maintenance activities. The concept of project success has also been quantified by establishing a MAI for building maintenance managements from the perceptions of building maintenance expects. Benchmarking practice and performance measures indeed provide a reasonable indication of the adequacy of a management system (Stevanovic et al., 2005). Building stakeholders can make use of the index as an indicator to know their relative position and compare the overall performance level with other building maintenance managements. The research enhances better understanding of building owners, occupants, end-users as well as building maintenance personnel to run a building maintenance activities or tasks successfully and provides constructive insights into the knowledge of building maintenance performance measurement. It should be useful for building stakeholders to communicate among themselves about the abstract concept of "success" for building maintenance managements and compare the success level with other maintenance managements scientifically.

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