

Creating Maintenance Cost Model for University Buildings

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Abstract—Maintenance costs incurred on building differs. The difference can be as results of the types, functions, age, building health index, size, form height, location and complexity of the building. These are contributing to the difficulty in maintenance development of deterministic maintenance cost model. This paper is concerns with reporting the preliminary findings on the creation of building maintenance cost distributions for universities in Malaysia. This study is triggered by the need to provide guides on maintenance costs distributions for decision making. For this purpose, a survey questionnaire was conducted to investigate the distribution of maintenance costs in the universities. Altogether, responses were received from twenty universities comprising both private and publicly owned. The research found that engineering services, roofing and finishes were the elements contributing the larger segment of the maintenance costs. Furthermore, the study indicates the significance of maintenance cost distribution as decision making tool towards maintenance management.

Keywords—Performance matrix, university buildings, cost model, Malaysia

I. INTRODUCTION

THIS research as part of a larger research project developing systemic building maintenance management model for universities in Malaysia, explores the maintenance cost distributions of universities. In order to achieve it main aim, analyses of maintenance expenditure in university buildings were conducted. Primary data is collected through survey questionnaire. The purpose of maintenance cost modeling is to provide realistic information to the maintenance organization in order to facilitate the decision making processes and procedures.

The study identified engineering service as the major element in maintenance cost distribution with a index score of 3.83 measured on a continuum scale of 1 to 5 and the least elements are foundations and frame with equal mean score of 2 points.

The paper is organized into the following sections. It commences with introduction in Section I. Section II discusses the design and methodology used for the study. In section III, the background to the study is provided along with the theoretical framework. The importance of university building maintenance in providing quality education is also provided in the section III.

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Section IV reviewed literature on the procurement of maintenance service. The section specifically discusses the requirements of each of the procurement strategies: in-sourcing and outsourcing.

Section V contains the research findings and discussion. The paper is concluded in section VI by bringing together the major themes of the paper.

II. RESEARCH DESIGN

A survey questionnaire approach was used to collect primary data for this research. As part of an ongoing research on the validation of systemic building maintenance management model that was developed for Malaysian university organizations, question was specifically addressed to the participants concerning the distribution of their maintenance cost. The survey commenced in October 2010 through January 2011. Official information indicates there were 50 universities in Malaysia with about 21 publicly owned while the remaining is privately owned. Therefore, 50 questionnaires were e-mailed to senior personnel in the university maintenance departments. However, by the cut of date, only ten responded.

In order to bolster the response rate, a face to face interview was scheduled with ten selected personnel in the university maintenance departments. Therefore, the face to face study comprised of 10 universities. Information that relate to maintenance costs were collated and process for this study. The face to face interview does not involve those that had responded through the e-mailed. However, only 7 among those that responded through e-mail provided a response to the questionnaires on the maintenance cost distributions. In other words, the maintenance costs distributions are based on 17 universities. All the universities are recognized in Malaysia.

Thirteen major building elements were identified and addressed to the participants to rate each of the elements with regards to the extents at which each of the elements contribute to total cost of maintenance. The extents were measured on 5 continuum scale of: very small extent (1: 10%- 20%); small extent (2: 20%-40%); somewhat extent (3: 40%-60%); high extent (4: 60%-80%); and highest extent (5: 80%-100%).

III. BACKGROUND AND THEORETICAL FRAMEWORK

Malaysian quest to high-income status by 2020 and beyond involves intensive transformation of the economic structure. However, as a panacea to this objective, the supply and availability of market driven workforce is prominent. In order to produce graduates that the market wants (knowledge workers), there is the need for high performance universities. High performance universities entail universities with high

performance assets and facilities. In other words, the assets of the university must be in optimum operable performance at all times in order to deliver quality educations.

University assets are funds, technology, human capital, equipments, plants and buildings. Although, human capital is university's most significant resource, because university educations are labour intensive, but apart from human resource, building is the most valuable asset of the university. University needs buildings to operate its business. The virtual universities also require some minimum amount of buildings to perform their roles of educating students.

University buildings are used as offices, lounges, reception areas, conference / seminar rooms, stores, treatment rooms, workroom for equipments (photocopiers, fax machines, printers) and mailbox. Other includes classrooms, teaching and research laboratories, libraries, residence halls, cafeteria, places of worship (Mosque), tea rooms and athletic facilities. Specifically, university buildings are procured to create a suitable, conducive, and adequate environment to support, stimulate and encourage learning, teaching, innovations and researches [1].

There are sufficient studies to conclude that the performance of educational buildings has a significant impact on both student performance and faculty members' productivity [2, 3 and 4]. While new buildings help to upgrade educational facilities and provide better quality educations, buildings cannot remain new throughout their life span. Because, building materials and components have finite life spans. It is also not realistic to replace, construct, refurbish or convert all of a university's buildings at one time considering the political, economic and social impacts.

An illustration of this is the replacement costs of the 1960s buildings in English universities alone which is estimated to be in the region of £11 billion [5]. Yet, buildings are not maintenance free. Building that will not require maintenance during its life span will have to compromise on its life span and performance. The conditions, appearance and performance of building depend on its functional requirements.

About 75% of the total expenditure on life cycle cost of a building is attributed to maintenance [6]. More than 90% of the life cycle of building projects requires maintenance [7]. In fact when salaries and benefits of maintenance staffs are added to maintenance expenditures / allocations, design and construction costs only contribute about 1% of building whole cycle cost [8]. Thus, the need for maintenance in buildings will only intensify as buildings require maintenance to retain and improve its value. Maintenance constantly affects students and faculty members' lives because their comfort, safety, pleasant and productivity are related to the performance of the buildings they live, learn, teach or and conduct research.

However, university stakeholders may not attach the same importance to the building as in the case of hotel and recreational sectors. For instance, the parents, students and faculty members pay much attention on the availability of latest and relevant reading, learning and research materials. However, times have moved on, there are greater concerns and

pressures on the university to ensure optimum performance of the buildings in order to be competitive, attractive and innovative [9].

Universities (i.e. public universities in particular) are now under intensive pressures as results of government action on slashing allocations to universities. Yet, universities cannot increase fees without a serious reaction or action from the students, parents and concern stakeholders. Such ugly reactions were witnessed last year when universities in the UK attempt to increase fees. The first sector / division in the university that normally suffer reduction in allocation when university subvention is reduced are the maintenance department. Unfortunately, however, during booming, the departments still suffer some neglect in terms of allocations.

A greater understanding of the building performance is shifting the whole lots of pressure to the university's maintenance department. Time, users' experience, perceptions and expectations are challenging the traditional approaches to maintenance. Building performance rather than the building condition now takes the centre stage. There are continuing realizations that the maintenance department should be considered as a University Strategic Business Unit or USBUs. By this, the maintenance department would be innovative, creative and competitive. Currently, however, universities do not consider building management as part of their core business. Instead, it is regarded as liability, or necessary evil, that cost what it will cost no matter what. This perspective is unfortunate, however. Universities need to consider buildings as factor of production like human capital, fund and technologies [1]. Considering, the fact that building could account up to 90% of asset value in the university's balance sheet.

IV. PROCURING MAINTENANCE SERVICE

Organizations currently favour two maintenance procurement structures. The first favour in-house maintenance while the other favour independent organization to carry out the maintenance work-outsource-. However, most organizations usually mixed the structures for better outcomes. The extent of which depends on the capacity and capability of the parent organizations and that of the maintenance organization as well [1]. The structure to use also depends on the nature of business of the organization. For, universities often consider managing their building is not their core - business as such prefers to outsource it, even though building constitutes larger share of the university assets. A part from the staff salary, building takes the larger share of university expenditure.

However, each of the structure has its advantages and disadvantages that should be looked at along with the nature of the organization's business objectives. For instance the in-house system is criticized to lack transparency and providing services of lower quality. It is also criticized for lack of proper documentations and leaving little room for flexibility for knowledge transfer. On the other hand, outsourcing strategy does not ensure proper transfer of documentation from one outsourcer to another outsourcer. Usually a maintenance

contract terminates after an agreed number of period (often between one year and five years) which is subject to renewal as the client organization deemed fit. At the end of the contract period, if the outsourcer failed to win the bid, the problems that often arise is problem of transferring the documents and experience from the organization to another organization that won the current contract.

Outsourcing exposes client organization to external threat as the contractors have access to some vital information. Outsourcing maintenance always reduces maintenance procurement to lump sum. However, the risk and uncertainty involves with maintenance services dictate that the traditional lump sum is undoubtedly unsuitable for maintenance works. The example of this can now be cited. Lump sum contract demand that the work to execute can be measured [10]. Otherwise, this could leads to adversarial relationship between contractor and client's with issue of claims.

Another criterion that often determines the procurement approach to be selected for maintenance works is conditions and performance of the existing facility [11]. The level of technological development and advancement should be taken into account, because some of the existing components and materials might already be outdated. For the procurement of new building, the contract covers legal matter in case of disputes among parties but in case of maintenance contract since no any new product is built or constructed, the maintenance contract is more of instruction [11]. This becomes very important, as no new project is "delivered", but it is only improvement that is sometimes noticed in future when the maintenance is most desirable.

V. DATA ANALYSIS AND RESULTS

A. Background information

The climate in Malaysia is hot tropical with high relative humidity. The temperature ranging between 22⁰C and 33⁰ C. University buildings in are characterized with frame structures, solid bricks, cement and sand mortar bed and joints. The windows and doors are in metal or and glass and aluminium, timber and steel joinery. The buildings are mostly roofed in brick slate or aluminium sheets. The floors are mainly finished in ceramic / or marble tiles on screeded bed. Sanitary appliances and fittings were ceramic wares.

Split air condition are predominantly used in the offices, lecture theatres, laboratories and lecture rooms while three bladed fans are popular in the student residences. The walls are plastered and rendered in cement and sand prepares to emulsion paints.

The maintenance managers of universities managed extensive array of buildings such as residential (hostels and staff apartments), administrative, academic and religious (e.g. Mosques) buildings. Unfortunately, there is no much this study can borrowed from available literature with respect to building maintenance costs distribution in Malaysia. Therefore, the outcome of this research cannot be compared with the outcomes of existing body of knowledge.

The participants have between 5 and 27 years industrial experience with the asset, facilities or maintenance organizations of their respective universities. The designations of the participants are contains Table 1. The maintenance index of about half of the universities are between 1% and 2%. However, in many of the universities it is between 4% and 8%. Maintenance index is the fraction of annual maintenance expenditure with the total building value of the university.

TABLE I
MAINTENANCE PERFORMANCE MATRIX

Designation	Frequency	Percentage
Maintenance manager, engineer, <i>etc.</i>	5	29.42
Director of Development Division and facilities	5	29.42
Head of Facilities and Maintenance Division	3	17.65
Administrators and others	4	23.53
Total	17	100

In terms of number of buildings on university campus (and including the staff residence), Table II indicates that half of the universities have less than 50 buildings each. None of the universities has more than 500 buildings in their portfolio although one each as 250 to 300, 350 to 400 and 450 to 500 each in their portfolio.

TABLE II
MAINTENANCE PERFORMANCE MATRIX

Number of building	Frequency	Percentage
Less than 50	8	50
50 to 100	2	12.5
150 to 200	3	18.75
200 to 250	0	0
250 to 300	1	6.25
350 to 400	1	6.25
450 to 500	1	6.25
500 and above	0	0
Total	16	100

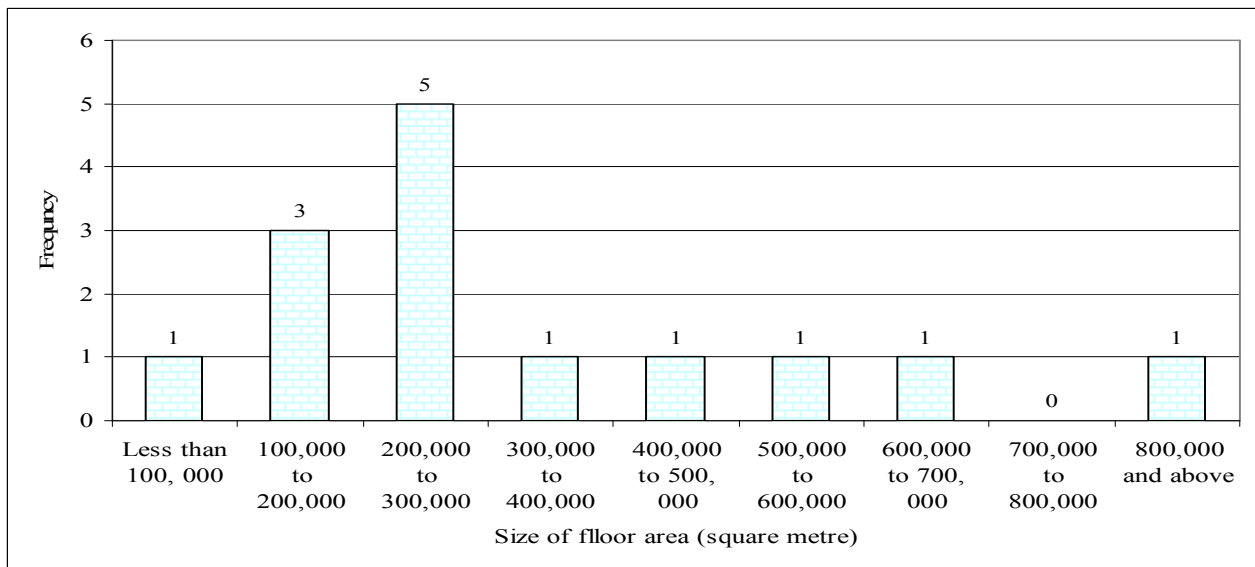


Fig. 1 Size of floor area of the buildings

The Histogram in Fig. 1 is information on the floor area of the survey universities. The histogram indicates the floor area of the buildings (in square meter) of most of the universities is 200,000m² to 300,000m². A university has more than 800,000 m² gross floor area. Considering the respondents' positions and industrial experience, and the size of the characteristic of buildings, the respondents are capable of providing unbiased and factual information that can be reported.

B. Maintenance cost distribution

This section provides information to achieve the aim of the study, specifically it explore the distribution of maintenance costs in Malaysian universities. It is intended to provide a guide to university maintenance department on maintenance allocation. The criteria were analyzed by mean of the following equation (1):

$$ExtentIndex = \frac{\sum_{i=1}^n w_i \times f_{xi}}{5n} \tag{1}$$

Where w_i is weight given to i th response; $i = 1, 2, 3, 4$ or 5 , is response frequency; f_{x1} is very small extent and f_{x5} is of highest extent and n is the total number of responses. Altogether, there are 17 respondents, however, while some respondents provided answered to all the elements, some did not.

For instance, the total number of respondents that indicated the extent of maintenance costs on lifts and escalators are fifteen. However, the biases such responses could have on data analysis have been minimized or eradicated with the used of the index equation.

In Table III is a list of building elements against the extent of which each contributes to maintenance costs. The combined average mean score for the element is 2.90. Nine elements have their individual mean score more than the average means score (2.9). The element contributing the highest maintenance costs is engineering service, with index score of 3.83.

Following the engineering service is roofing ($w_m=3.59$). The elements contributing the least are foundations and frames, each contributing "small extent" to the total annual maintenance costs. The percentage of total distribution is obtained on the basis of the mean score. For instance, the sum of the total mean score is equated to a 100%. On that basis, the percentage contribution of each element is obtained as a fraction of the 100%. Therefore, engineering services account for about 10% of maintenance cost while foundation and frames take about 5% on the maintenance cost each respectively.

TABLE III
DISTRIBUTION OF DESCRIPTIVE STATISTICS OF MAINTENANCE COST

Criteria	Frequency	1	2	3	4	5	Extent Index	% of total distribution	Ranking
Foundations	17	9	3	2	2	1	2.00	5.32	12
% of respondents		52.94	17.65	11.77	11.77	5.88			
Frames (columns and beams)	16	7	5	1	3	0	2.00	5.32	13
% of respondents		43.75	31.25	6.25	18.75	0			
Staircases	16	4	7	4	1	0	2.13	5.66	11
% of respondents		25.00	43.75	25.00	6.25	0			
Upper floors	16	4	5	5	2	0	2.32	6.17	10
% of respondents		25.00	31.25	31.35	12.50	0			
Roofing	17	0	2	6	6	3	3.59	9.55	2
% of respondents		0	11.75	35.30	35.30	17.65			
External walls	16	0	4	8	4	0	3.00	7.98	8
% of respondents		0	25.00	50.00	25.00	0			
Internal walls and partitions	17	1	3	7	6	0	3.06	8.14	6
% of respondents		5.88	17.65	41.77	35.29	0			
Windows	16	2	3	7	3	1	2.88	7.65	9
% of respondents		12.50	18.75	43.75	18.75	6.25			
Doors	17	1	5	4	7	0	3.00	7.99	7
% of respondents		5.88	29.41	23.53	41.17	0			
Finishes	17	0	5	3	8	1	3.29	8.77	3
% of respondents		0	29.41	17.65	47.06	5.88			
Decorations and painting	17	0	4	7	5	1	3.18	8.45	4
% of respondents		0	23.53	41.17	29.41	5.88			
Lifts and escalators	15	0	3	7	5	0	3.13	8.34	5
% of respondents		0	20.00	46.67	33.33	0			
Engineering services	17	0	1	5	7	4	3.83	10.18	1
% of respondents		0	5.88	29.41	41.17	23.53			

VI. DISCUSSIONS

However, the findings of this study are not unexpected. Engineering services are major contributors to maintenance costs. Although, larger part of the problem is due to poor design, much of the problems can be reduced by systemic maintenance management. Considering also the climatic weather condition in Malaysia, roof maintenance could contribute significantly to maintenance costs.

While the problem might not be with the materials, labour is high particularly as there are many tall buildings in the campuses so some maintenance request could involve the use of crane, plants and equipments. In general, however, one will need to category maintenance into two main sections. Maintenance could be seen in terms of volume of work or in terms expenditure. For instance, while roof repair is not a daily occurrence, if roofs required maintenance it usually requires enormous budgets. This is also the case, with elements like frames and foundations.

Foundations seldom failed, but in case it failed, usually specialists will be required for the maintenance. For which the university maintenance department, which usually is a small unit, cannot handle the required works loads and expertise.

However, same arguments cannot be made for finishes, engineering services, decoration and painting, and internal walls and partitions and even lifts and escalators. While escalators are specialist equipments, it seldom failed if proper preventive maintenance is administered. The manufacturers as a matter of requirements furnish the buyers with manuals and catalogues. Therefore, the arguments that university outsourced maintenance service because of lack of specialists and materials and components cannot be supported.

This is an illustration. Substantial part of the items that often require maintenance under the engineering service are electrical circuit, air conditioning system, towel rail, sanitary appliances and fittings, water closet, pipes leakage and sink leakage / blockage. The finishes are mostly ceramic floor and wall tiles. Furthermore, the paints are commonly emulsion and gloss. In another context, some of the participants that responded to the question "Others please specify", list the following elements as the elements that contribute to

maintenance cost: sewage, cleaning, administrative charges and furniture.

While university maintenance organization could claim not having the expertise to repair foundations or structure, they could not claim same for the maintenance of services. Although, the manufacturer's manual or guideline cannot entirely be relied upon, because they are often prepared for ideal or normal condition which is not often the case in reality but it is a good guide. Therefore, in addition to the manufacturer's catalogues, the intensity of usage and local factors, existing performance, nature of users and previous maintenance records should be used by the university to plan and forecast maintenance demand for equipments and plants maintenance.

However, to most university managing the building is not part of their core business as a result preferred to outsource it to contractor. But, this thinking is gradually becoming outdated, as universities are realizing the need to manage their building along with other asset based of their university. However, it could be argued that not considering building as a factor production by the university is failure on the part of the sector that pride itself as repository of knowledge. Perhaps, there is the need to engage some of the relevant faculty members in the maintenance organizations. The university ought to provide the direction for the practitioners after all the practitioners pass through university at one point or the other. However, it is often suggested that it is in the best interest for organization with large capital based to create an independent maintenance management organization.

VII. CONCLUSION

In anticipation of larger research on maintenance of university buildings in Malaysia, this study has indicated that university can opt to in-source larger part of services. A great number of universities claimed that a basic reason for outsourcing maintenance is due to their inability to stock the necessary materials and components. Therefore, study is required to develop maintenance costs model. By this, universities could stock the materials and components in to facilitate in-house procurement.

However, on the nature and class of elements in the buildings as identified in this research, this claim may not be substantiated, even the number of participants is not large enough. The results of the models are typically necessary to obtain approval to proceed, and are factored into business plans, budgets, and other financial planning and tracking mechanisms.

Maintenance cost is an important element that should be monitored from time to time to produce more realistic estimate for the maintenance. Though the list of the 13 elements may not be exhaustive due to the vast nature of the building maintenance concurrently with the problem of nomenclature the list is an indicative of major maintenance elements that are attributable to much of the maintenance costs. The failure of universities to accept maintenance as a core service is serious failure to a sector that prides itself as vehicle for scientific and technological advancement.

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