OPTIMAL LIFE CYCLE COSTING ANALYSIS FOR FACULTY OF GEOINFORMATION SCIENCE AND ENGINEERING FLOOR'S MATERIAL

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Abstract

One of the biggest challenges facing regulated utilities today is aligning the management of their infrastructure with corporate objectives. The emerging discipline of asset management is a promising approach to this problem, because it can do things that techniques such as balanced scorecards and total quality cannot. Decisions must be made about operating and maintaining infrastructure assets. A misguided perception of life cycle costing is that the longer something lasts, the less it costs over time. The purpose of this research is to examine flooring materials including ceramic, homogeneous, vinyl and carpet for the Faculty of Geoinformation Science and Engineering. Besides, this paper concern of the creation of a decision making tool based on real life data that will facilitate practical evaluation of flooring materials. A life cycle cost (LCC) analysis will be used as an economic evaluation tool. LCCA quantifies incurring costs commonly overlooked (by property and asset managers and designers) as replacement and maintenance costs. The impact of the used substrate materials and the installation methods used for each alternative will be assessed for possible potential effects on the service life cycle cost. Using the life cycle cost analysis (LCCA), the true cost of each material will be computed projecting 60 years as the building service life and 5.4% as the inflation rate percentage.

Keywords: Life Cycle Costing Analysis, Assets, Flooring Material

INTRODUCTION

For the last two decade, the growing recognition of property and assets management (PAM) as a management process that embrace the whole life of an asset, has had the impact of raising the awareness to the need to consider the operational period of building assets. There is a growing recognition of a need for a property management budgeting method that gives proper evaluation to overall cost of the asset including their operational and maintenance expenses throughout its life-cycle. As in general Malaysia property management-asset significances, budgeting would be the vital practice in this country for the beginners before applying the advanced method in PAM. Synchronize to that needs, researcher will expand this study to implement the life cycle costs analysis (LCCA) to the property and asset management community at Faculty of Geoinformation Science and Engineering to give them an idea about the benefits of LCCA for the period of the decision making process and cost effective.

Malaysia as one of the development countries in South East Asia was growing

rapidly almost in all sectors. Despite of that, there are still lacking in managing the correct way especially in property and assets management requirement. To meet the high demand of public and private sectors, it is expected that many error and deficiency will have occurred during the design and construction phase of the project, later resulting the high cost of property and assets maintenance. The proper selection of the asset material for any building contributes considerably to the overall life cycle cost (LCC) of a building. As a simple task given until the asset fix to the building, it will involve the cost. However, the selection of the materials is typically based on manufacturer's information, property professional, asset professional or the initial const of the product and budget constraints.

By respecting to the physical asset management, many of them focusing on the maintenance management models and tools (Amadi-Echendu, 2004; Harvey, 1976). Dealing to Waeyenbergh, and Pintelon, (2002), they mention that an asset proceeds through a number of sequential phases during its life cycle; acquisition, operation and maintenance, refurbishment or enhancement, and, finally, disposal. The life cycle of an asset begins with a planning process that identifies the need for that asset and determines how and when it is to be procured (Department of Public Work, Queensland, 1996). The asset is then acquired either an existing asset is purchased or a new one is created. The asset then enters its operational phase. As the asset ages, it may deteriorate or become obsolete, at which stage a decision is made to either refurbish, enhance or dispose of it.

Budgeting is most often thought of as having to do with the planning and control of revenues and expense, such as with managing the common operations of a business or other organization (Lally, 2003). Profit budget gets most attention, because it is the area of the primary goal of a business. Therefore in many companies the balance sheet and cash flow statements are left to their own devices. Nevertheless, the fact on balance sheet budget and cash flow budget are logical supplements to an operating budget and bring many benefits, though less apparent; they are more profound and lasting especially in providing supports for financial decision making (Dunk, 2004, pp.401-414).

On the other hand, where customer loyalty is volatile, product life cycle are shortening, competitors can arise suddenly from anywhere and the best people are attracted to organizations that promote supervisory freedom and responsibility, the traditional budgeting approach is a severe handicap. Put another way, budgets are barriers to competitive success economic resources. The use of alternative systems of budgeting usually makes financial decision making processes more complicated due to time pressure (Myers, 2001, pp.81-102). Although budgeting is the solution process through which supervision can change and direct the organization's performance, it is not good enough just to make the process more efficient. After all, a simple shortening of the budgeting cycle by one month does not put a stop to the fact that the resulting budget is still irrelevant after only a few months. The focus of any revised budgeting process has to be on helping the organization compete more effectively in the market.

One possible way is to focus the budgeting process on implementation of the strategy, and it has to add value to the organization (Lally, 2003). Therefore, the budgeting model must be designed around the strategies and the associated tactical plans. On the other hand, quick updating of budgeted data is one of the indispensable conditions for the following budgeting

process reorganization and turning to alternative systems such as rolling budget or forecasts, which are updated every few months in effect, reassessing the company's outlook several times a year.

Changing approaches to an old dilemma are not merely of academic interest. All of the approaches to the basic budgeting problem whether normative or positivist in target, have influenced the design of budget institutions, procedures and analytical methods. Changes in budget practice moreover, tended to proceed incrementally and cumulatively, so that many of the innovations introduced in early reforms are still in place at present. Thus, nowadays budget structures are essentially the same as those introduced in the late 19th centuries when modern budgeting systems were first established. Similarly, the analytical methods and process proposed by rationalists in the 1960s persist to be used these days. Indeed, the rationalist approach is still the prevailing paradigm for policy makers.

Schools and other public services in which access can be restricted share these characteristics (Khumalo and Wright, 1997, pp.155-168). In addition, Suthiwart Narueput (1998, pp.1-35) demonstrates that a large proportion of public expenditures is allocated in the provision of private goods that could, and by implication should, be provided and financed by the private sector. Notwithstanding the sensitivity of the results to the scope of impact analysis, cost and benefit valuations, discount rates and the distributional weightings applied, the technique does provide a rigorous basis for decision making at this level. Unfortunately application of the technique to higher level, inter sectoral and inter programme allocation decisions is impractical owing to information constraints.

Although the general principle of benefit valuation can be applied, this can only be considered an approximate cost benefit measurement based on the valuation of a narrow range of direct impacts (Pradhan, 1996, pp.99-105). The nature of the budget process also promotes incremental decision making. Furthermore, budgeting is repetitive, with the same allocation issues being addressed in successive budgeting exercises. In this way, participants arrive at an implicit agreement regarding each claimant's fair share and, constituting a convergence of expectation on roughly how much an agency is to receive in comparison to others (Wildavsky, 1992).

Additionally, the experienced of Amadi-Echendu, (2004) in order to keep going the value of the assets, the assets management requires beyond typical cost principles of maintenance. Real estate asset management offers a structure approach in handling real estate assets considering all the factors that accompanies investing in real estate. It may be described as the systematic process of maintaining and upgrading real estate assets in a cost effective manner that would work well for the property owner.

MODIFICATIONS NEEDED

Most of the organisations have a culture that is focused on the financial and service they provide. In such a culture, people are naturally inclined to emphasis issues that are tangible, visible or measurable. Come to the problems, Property Managers be inclined to consider that the focus on financial, process and process improvements result in productivity increases.

Cost of asset ownership is playing a pivotal role in performance assessment. As a result, organizations are being encouraged to increase accountability and minimize risk through more comprehensive and innovative asset management techniques. Life cycle costing strategies are steadily

replacing traditional costing tools in a move to identify and monitor long-term cost of ownership. By extending previous calculations to include customer, social and environment considerations, life cycle costing can provide a valuable tool in assessing economic efficiency in complex infrastructure asset management. The question then becomes how to identify, analyze and respond to ever changing costs throughout the development, building, maintenance and end stages of a complex asset.

Organisations of all kinds in different economics around the world recognise that the rising costs of occupying buildings, materials, providing services to support business operations and improving working conditions are important factors in profitability. Amaratunga, D., Sharshar, M., and Baldry, D., (2002), emphasise that the organisations need to find the right balance between focusing on the product and focusing on process together with the life cycles.

The following changes in design, assets procedures and construction methods provided once in a lifetime opportunity to study the life cycle costs of flooring materials at the Faculty of Geoinformation Science and Engineering building.

Regarding to Universiti Teknologi Malaysia-Skudai campus, (UTM)'s maintenance and asset management necessity, it is important to identify whether the present maintenance management implemented of furnishes especially the flooring materials is still suitable or not. The development of the faculty building in UTM since 1975 has dramatically changes the assets provided. The different in assets and renovations that had been made would trigger different maintenance dealing which requires the study to identify whether the present maintenance management is still acceptable or can be replacing with looking into consideration of implication of the Life Cycle Costs Analysis in decision making process at earlier stage. The new of implementation perhaps can be easier and more effective with less costly.

SIGNIFICANCE OF THE PROBLEM

The study focuses on the Faculty of Geoinformation Science and Engineering, Universiti Teknologi Malaysia, Skudai. This building uses varieties of flooring materials depend to the departments' placed. This building is essentially among the earliest building construct in UTM, it is of primary importance to know if the flooring materials used is the best alternatives when maintenance and operational costs are considered.

The objective of LCCA is to choose the most cost effective approach from a series of alternatives to achieve the lowest long-term cost of ownership. LCCA is an economic model over the project life span. Usually the cost of operation, maintenance, and disposal costs exceed all other first costs many times. The best balance among cost elements is achieved when the total LCCA is minimized. As with most engineering tools, LCCA provides best results when both engineering art and science are merged with a good judgment.

This research uses a life cycle cost analysis as a method of depicting the true overall cost of each floor covering over a predetermined period of time. Life cycle cost analysis can appear complicated and difficult to comprehend from the standpoint of establishing the real value of a floor covering expenditure. Selecting the materials and components of the floor based on a life cycle cost analysis can significantly decrease the lifetime cost of construction, maintenance and repair.

Together with that, selecting materials and components based on initial costs disregards future costs over the intended life of the system such as maintenance, repair, and reconstruction.

The initial purchase cost, installation charges, maintenance requirement and associated costs, plus the costs of cleaning chemicals must be factored into the analysis to yield the true expenditure of money over a period of time. The result of the life cycle cost analysis is intended to be a quantitative decision-making tool that will allow design professionals and asset managers to make informed choices about asset flooring materials prior to incurring replacement restoration expenses.

For the purpose of this research, flooring material finishes are studied and compared. "As a finish material, it is often considered the most important specification in the interior design scheme. Floor finishes choices create an opportunity to expand a colour palette and specify a product that is conductive to the type of activities and purpose of the building" (Harris, 2000).

Floor surfaces are daily exposed to foot and equipment traffic, exposure to direct and indirect sunlight, and possible contamination of organic and chemical sources. Another important issue of flooring materials is associated with safety. "Floor surfaces are a crucial factor in preventing falls and need very careful consideration in relation to anticipated users and patterns of use and behaviour . . . there is no such thing as a non-slip floor"(Berman, 1997).

METHODOLOGY

In the effort to meet the ultimate research objective, the following research methodologies are being considered in the process of generating fundamental understanding in property and assets management and the analysis of archives data on property and assets build at the area of study scope;

1. Literature review.
2. Conducting a structure questionnaire to interview the person-in-charge of the property and assets.
3. Analysis of archive data on property and assets (refer to the floor's material)

PROJECT BACKGROUND

The completed study was conducted in phases whereby the first phases consisted of reviewing the official documents such as specifications, drawings, finishes schedules, and purchase invoices. The second phase required the collection of the empirical data regarding the construction of the building performance, cleaning procedures, repair and maintenance and replacement of the building materials. The third phases are involved the calculation of the empirical data in LCC with manufacturer standard of the products currently in used. The last phase was to collect, compile and analyse the gathered data using the methods of LCC measurement.

Phase I: Analysis of Official Documents

The Faculty of Geoinformation Science and Engineering (FKSG), Universiti Teknologi Malaysia, provided official documents such as construction documents and specifications, AutoCAD Drawing, finishes schedules and purchase invoice for Faculty of Geoinformation Science and Engineering. Those documents provided the information regarding the type of flooring material used, the manufacturers, initial cost, total area for each material been used and the systems specification. The data collected on this stage is summarized at Table 1: Material used at Faculty of Geoinformation Science and Engineering.

Table 1: Material Used at Faculty of Geoinformation Science and Engineering.

MATERIAL	TOTAL AREA (SQ.FT)	MANUFACTURER	TYPE	COLOUR
Ceramic Tile	**45,438.11**	DuroGres CERAMIC TILES	Floor Class II-Medium [30cmx30cm]	String Gray
Homogeneous Tile	**40,655.15**	NIRO GRANITE THE SWISS QUALITY TILE	Floor Class II-Medium [5cm x 5cm]	Tinsel Cream Pearl White
Vinyl	**20,327.58**	Durafloor House of Vinyl Flooring	Floor Class II-Medium [30cmx30cm]	Vivid Blue Medium Gray
Carpet	**15,544.62**	floorStyle malaysia sdn. bhd.	Lexus Soft Class -Medium	Royal Blue

Source: Author, 2009

Besides that, the document also contained the information of the building plan (layout), location, and size of the building. All the documents used to create a preliminary list of material commonly used in FKSGs' asset.

Phase II: Empirical Data Collection

Survey and direct observations of the faculty's asset were used to collect empirical data. The Deputy Registrar at the Faculty of Geoinformation Science and Engineering, Universiti Teknologi Malaysia provided accurate information on the performance of flooring materials and the current cost of operating and maintaining them. Together with it, direct site observations were conducted at FKSG.

The information collected from direct observations included data on the service use of the flooring materials in the asset. The amounts of students who used the asset also have been observed by the researcher. Even though, almost all the data collected from the Deputy Registrar, researcher still doing the informal interview with university's maintenance staff, university's drawing planner staff, and university's cleaner staff to support the direct observations.

These interviews provided additional data regarding the custodial work salary, time consumed for various cleaning and repair procedures, actual type of equipment and cleaning materials used for regular maintenance, and frequency of standard operations and maintenance procedures.

After computing the data, floor area for the FKSG by referring to C01 to C06 are shown as below (Table 2).

Phase III: Materials Specifications and Standards

Once the flooring materials were identified, manufacturer's technical specification data sheet were collected. For each finish, these sheets provided information regarding the

Table 2: Floor Area Calculated Manually.

Block	∑ Floor Levels	Floor Area (m2)	Floor Area (ft2)
C01	1	98.998 m2	**1,065.605 ft²**
C02	4	4234.534 m2 x 4 levels – (35% of the ∑ Floor Area)	**118,508.3744 ft²**
C03	4		
C04	4		
C05	4	45580.144 ft² x 4 levels – (35% of the ∑ Floor Area) 118,508.3744 ft²	
C06	4		
		TOTAL AREA	**119,573.9794 ft²**

**35 % is including the Lecture Hall which is constraint 2 levels, spaces for the stairs, unneeded corridor, beams & columns.*
**1 square meter = 10.763911 square feet*

Source: Author, 2009

materials characteristics, recommended cleaning and maintenance procedure and expected durability. The information was used to compare the actual cleaning and maintenance procedures with those specified by manufacturer.

In addition, the Minimum Standards of Housing and Amenities Act 1990, Uniform Building (Amendment) By-laws (UBBL) 1991, and Guidelines used for Standards and Cost of Building Planning by Standard and Cost committee (2008) were used as a basis for refining the list of flooring alternatives.

Phase IV: LCC Analysis

A service life cycle cost analysis of actual projected cost for Faculty of Geoinformation Science and Engineering during the used and replacement of the flooring materials over a 60 years building service life was completed. For this reasons, the analysis consisted of a service LCCA comparison of selected materials. The Ringgit Malaysia values used in the LCCA calculations come from the monetary expenditure to purchase, properly maintain and replace these flooring materials to serve the building for 60 years.

Life Cycle Cost (LCC) Analysis Assumption

The basic assumptions (Table 3) for the LCC analysis are based on materials specifications and standards set by the Office of the Asset and Construction, Universiti Teknologi Malaysia-Skudai campus, Johor (OAC-UTM) and the Faculty of Geoinformation Science and Engineering, Universiti Teknologi Malaysia (FKSG-UTM). Besides that, all the assumption also based to the Malaysia's Prime Minister Malaysia's Office and Ministry of Works.

Selection of Materials for Analysis

For the purpose of this project, interior floor surface were studied, which include not only floor finishes but also the substrate or sub-floor where they are applied, and the material used to attach the finish to the substrate. Table 4 shows the floor surface material considered in the LCCA modus operandi. The materials major flooring characteristics and the actual maintenance procedures are listed. The table is divided into three segmentations which are sand to hard flooring categories, resilient flooring categories and soft flooring categories allowing for proper comparison between flooring alternatives.

Table 3: Basic Assumptions

Inflation Rate	A general inflation rate 5.4% was used based on the Department of Statistics Malaysia and BNM (January, 2009).
Discount Rate	The FKSG does not allocate funds for future replacements or maintenance cost, thus the discount factors said to be zero (0).
Operation and Maintenance	Maintainability can be defined as ease of which the maintenance activity can be carried out on an item of product or system (Rosenberg, 2000).
Building Service Life	A 60-years building service life
Initial Capital Cost	Based on contract and manufacturer's provided data, including material and installation.
System Service Life	Derived from the manufacturer's information and direct observations. It is assumed that the manufacturer's recommendation for cleaning and maintenance are performed.
Number of Replacement	Assumed to support the asset during the 60 years of expected service life.
Selvage Value	It is assumed that there is no salvage value at the time of replacement. Source: Author, 2009

RESEARCH DESIGN

Research designed for the purpose of producing results that may be applied to real world situations. It is also known as a plan outlining how information is to be gathered for an assessment or evaluation that includes identifying the data gathering method, the instruments to be created, how the instruments will be administered, and how the information will be organized and analysed.

Case Study Strategy

After researcher scanning and handling observation, it is come to the next action before continue with the analysis. This is call research design. The researcher will use the case study strategy for the development of this study. Groat and Wang (2002) define the case study as an empirical inquiry that investigate a phenomenon or setting, which includes historic phenomenon and both historic and contemporary setting as potential foci of case studies.

The essence of a case study strategy is its focus on studying a setting or phenomenon embedded in its real context. It implies much more than simply studying a phenomenon "in the field". Rather, it involves studying a case in relation to the complex dynamics with which it intersects (Groat and Wang, 2002). A case study can be based exclusively and quality data or have a theory driven focus.

Survey Analysis

Table 5 is broken into flooring systems: ceramic tile, homogeneous, vinyl and carpet. The information is a description of the materials used for evaluation. In this research all the systems were laid in the same type of substrate material and were installed accordingly to the manufacturer's specifications.

The second (2) columns represent the service life in years of each material. This information was obtained from manufacturer's specification data sheets. The third (3) columns is the capital cost which represent the Ringgit Malaysia values on a per square foot basis including materials and installation. Some of these values were obtain from record documents and others from direct interviews with manufacturers and suppliers. Column number four (4) is the cost of O&M for each material expressed as cost per square foot.

Table 4: Analysis of Life Cycle Costing Results

Types	Area %	Area (psf)	
		119,573.98	Total Area
Ceramic	38%	45,438.11	
Homogeneous	34%	40,655.15	
Vinyl	17%	20,327.58	
Carpet	13%	15,544.62	

Types	Initial Cost RMpsf	Life Span	Inflation Rate	O&M (%of Initial Cost)
Ceramic	1.87	50	5.40%	7.00%
Homogeneous	3.92	55	5.40%	18.00%
Vinyl	12.00	15	5.40%	32.00%
Carpet	2.7	10	5.40%	22.00%

Building Service Life	Cost of O&M RMpsf	Maintenance of the system -first year end	Increment Amount	
59	0.13	5,947.85	321.18	per year
59	0.71	28,686.28	1,549.06	per year
59	3.84	78,057.89	4,215.13	per year
59	0.59	9,233.50	498.61	per year

Types	A yearly cost for O&M	Annual Cost (uniform series) for the next 59 years	Present Worth Formula (59 years)
Ceramic	5,056.66	11,004.51	194,633.89
Homogeneous	24,388.12	53,074.39	938,712.74
Vinyl	66,362.22	144,420.12	2,554,320.37
Carpet	7,850.02	17,083.52	302,151.68

Types	LCC (RMpsf)
Ceramic	**30.22**
Homogeneous	**93.81**
Vinyl	**152.07**
Carpet	**24.01**

Source: Author, 2009

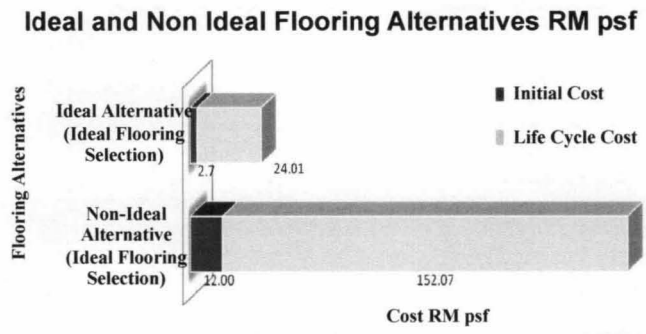
Table 5: Summary of Results

Types	Life Span	Initial Cost RMpsf	O&M (%of Initial Cost)	Cost of O&M RMpsf	LCC (RMpsf)	RANK
Ceramic	50	1.87	7.00%	0.13	**30.22**	2
Homogeneous	55	3.92	18.00%	0.71	**93.81**	3
Vinyl	15	12.00	32.00%	3.84	**152.07**	4
Carpet	10	2.70	22.00%	0.59	**24.01**	1

Source: Author, 2009

For example, a material with 50 year service life, an initial cost of RM 1.87 psf and an O&M cost equal to 7% of the initial cost would have an O&M cost of RM 0.13 psf. If the total area of that material is said to be 45,438.11 sf, then the total O&M cost for that system would be RM 84,969.27 year. It is assumed that the maintenance and operation cost will increase at a rate equal to the inflation over the service life of the system (i.e. 5.4%). The calculation is then repeated for the period of years from 11-20, 21-30, 31-40, 41-50, and 51-60. The value obtained is then brought back to the present using a zero discount rate value.

Column number five (5) is the Net Present Worth or Life Cycle Cost of the system, over a period of 60-year. This value takes into



Source: Author, 2009

Figure 1: Initial Cost versus Life Cycle Cost for Ideal and Non-ideal Flooring Alternatives

consideration: NPW of initial cost, NPW of O&M costs, and NPW of replacements. The last column shows a ranking system that organizes the materials in ascending order of NPW.

The flooring system rank one (1), ceramic tile is the preferred alternative based on LCC followed by Ceramic, Homogeneous and Vinyl. An important observation from the results is that the lowest initial cost is not necessarily the lowest cost based on the net present worth values. This means that there is no direct correlation between initial cost and life cycle cost results as seen in Figure 1. From the Table 5 it can be notice that carpet, which are ranked two (2) based on initial cost of RM 2.70 psf, are rank one (1) based on the NPW value of RM 24.01. Mean while ceramic, which are ranked one (1) based on initial cost of RM 1.87 psf, are rank two (2) based on the NPW value of RM 30.22; Homogeneous, which are ranked three (3) based on initial cost of RM 3.92 psf, are rank three (3) based on the NPW value of RM 93.81, and vinyl, which are ranked four (4) based on initial cost of RM 12.00 psf, are rank four (4) based on the NPW value of RM 152.07.

Table 7 shows that for an area of 5,000 sf of alternative flooring inverting RM 0.83 psf more in the initial cost of carpet would save the asset RM 31,050.00 over the service life of the asset of 60 years.

Table 8 shows the results of the analysis between LCC and O&M psf. There is a direct relationship between the total maintenance and operation cost per square feet of the material and the NPW (Figure 2). Figure 3 to Figure 5 shows the relationship between increasing O&M and NPW for type of materials such as carpet, ceramic, vinyl and homogeneous, as the service life increase the NPW decreases. This is because longer the service life of a material, fewer replacements, then lowers NPW values.

Upfront the purchase and installation costs of ceramic are less than those for carpet,

Table 6: Value Diverse for Initial Cost and LCC

Types	Life Span	Initial Cost RMpsf	LCC (RMpsf)	Value Diverse	RANK
Ceramic	50	1.87	**30.22**	28.35	2
Homogeneous	55	3.92	**93.81**	89.89	3
Vinyl	15	12.00	**152.07**	140.07	4
Carpet	10	2.7	**24.01**	21.31	1

Source: Author, 2009

Table 7 is an example that compares two alternatives assuming an area to be covered of 5,000 sf.

Table 7: Comparison Between a Low Initial Cost Alternative and a Low LCC Alternative

	Option One *Low Initial Cost*	**Option Two** *Low LCC*
Alternative Flooring	**Ceramic Tile**	**Carpet**
Initial Cost	RM1.87	RM2.70
Total NPW	RM30.22	RM24.01
Total Initial Cost	RM9M350.00	RM13,500.00
Total Life Cycle Coat	RM151,100.00	RM120,050.00
Additional Initial Cost Needed for Lower LCC Alternative	**RM4,150.00**	
Total Saving from LCC	**RM31,050.00**	

Source: Author, 2009

Table 8: Comparison Between a LCC and O&M Cost

Type	LCC (RMpsf)	O&M Cost (RMpsf)
Ceramic	**30.22**	**4.28**
Homogeneous	**93.81**	**23.09**
Vinyl	**152.07**	**125.66**
Carpet	**24.01**	**19.44**

Source: Author, 2009

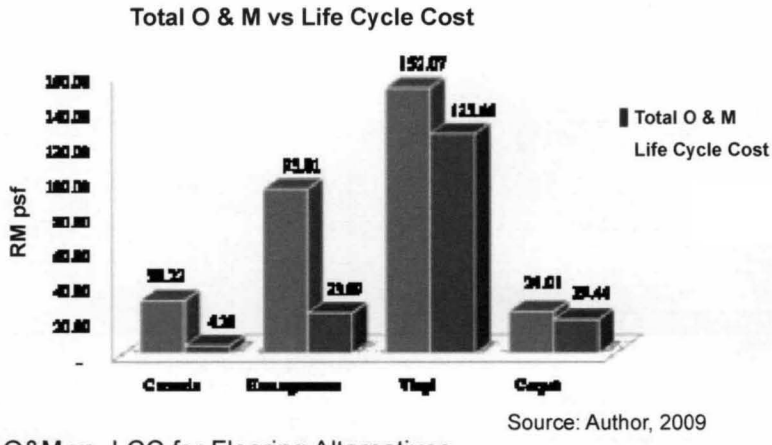
RM 1.87 psf and RM 2.70 psf respectively. However, at the end of the 60-year service life carpet is more cost efficient than ceramic. It cost 133% more to maintain and operate ceramic than carpet (Figure 6).

No correlation was found between service life values and values for NPW and O&M cost (Figure 7). For example, vinyl has the second lowest value for service life (15 years) but the highest value for life cycle cost, RM152.07. Homogeneous, which has the highest value of service life (55 years), has the runner up lowest value for maintenance and operational cost. A low service life value means more frequent replacements but does not means higher values for life cycle cost and/or maintenance costs.

CONCLUSION

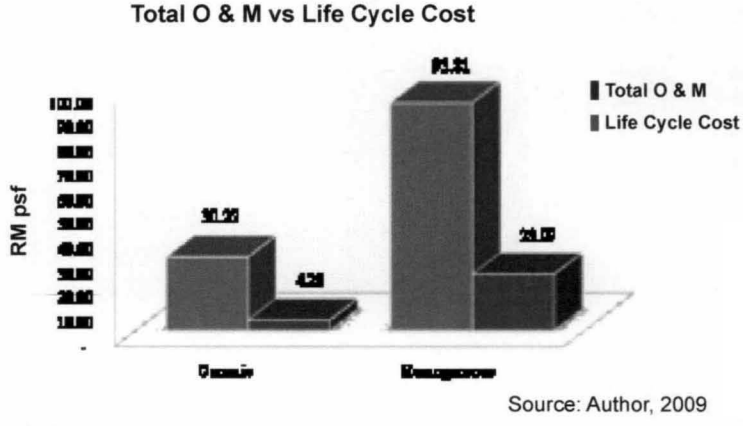
Life cycle costing can, therefore, be particularly useful when analysing the economics of decision regarding buildings, since they and their associated components often have long life cycles. As results, the benefits (or disadvantages) accrue over a long period of time. If the action leads to reduce costs over its lifetime, it can pay back any additional costs required to take the action and then save money over the long term.

It is clear from the earlier chapter that the task of providing and managing the Life-Cycle Cost Analysis within the Faculty of Geoinformation Science and Engineering setting is complex. Research on Faculty of



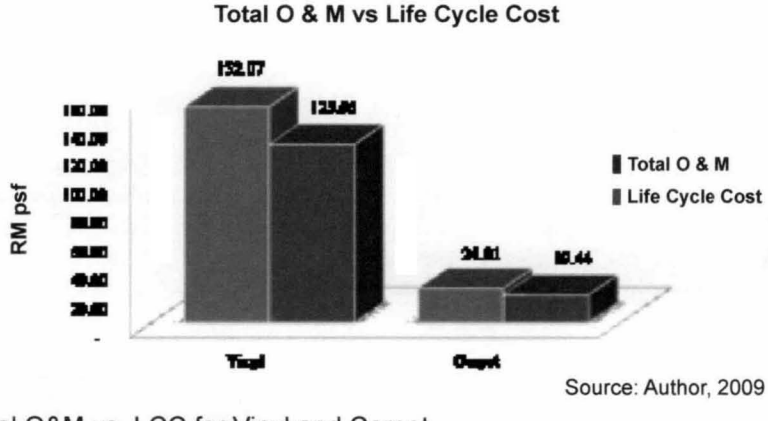
Source: Author, 2009

Figure 2: Total O&M vs. LCC for Flooring Alternatives



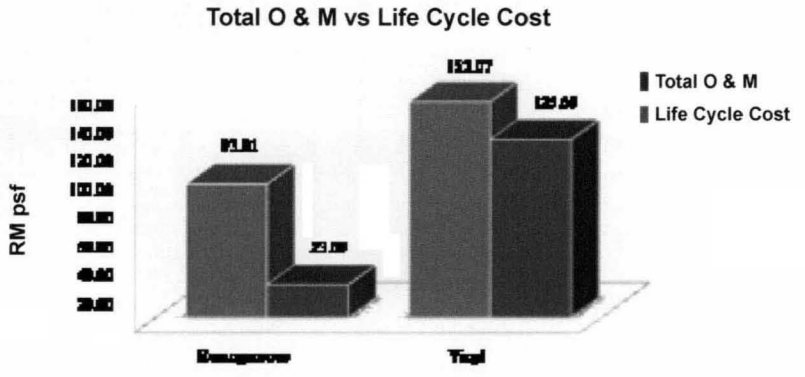
Source: Author, 2009

Figure 3: Total O&M vs. LCC for Ceramic and Homogeneous



Source: Author, 2009

Figure 4: Total O&M vs. LCC for Vinyl and Carpet



Source: Author, 2009

Figure 5: Total O&M vs. LCC for Homogeneous and Vinyl

Geoinformation Science and Engineering asset management (FKSG-asset) is limited to the scope of instruction. Moreover, the research conducted to date is to value in illustrating the consequences of FSG-asset. Therefore, it is important to distinguish every single vital data towards asset of flooring materials had been calculated in to the formula.

Flooring selection for educational assets is not an easy task. The process should take into account the needs of the users, and the physical qualities of the space. Also, design professionals need to understand the impact that their selection of materials may have on the users and on the global environment. Due to the rapidly growing worldwide interest in achieving global sustainability, a special interest should be placed on the selection of environmentally friendly materials. However, a successful design does not conclude with the proper and responsible selection of materials.

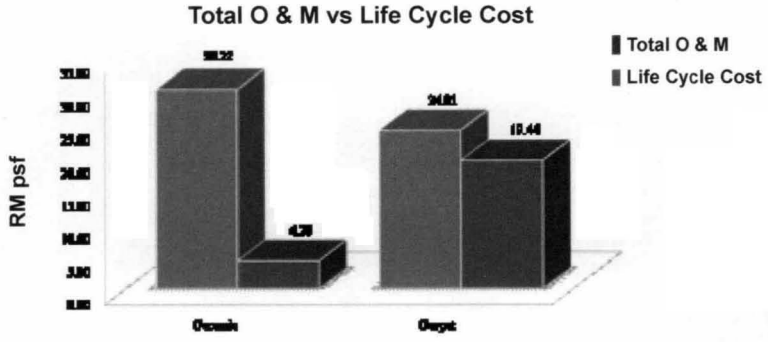
Critical Success Factor for LCC

Choosing flooring material as an asset based for the property management case study is one of the initial idea to show the impact. Any flooring substitute chosen is dependent upon the maintenance program (cleaning, replacement and repair) and is appropriate implementations. Lower initial cost materials are of little benefit if the maintenance costs are beyond the asset budget.

For this reason an ideal choice for selecting flooring material is a low LCC material. These materials will have a little cost after the original capital cost. Other materials may or may not have low initial cost but they will always have high values of LCC. A low life-cycle cost material may not be suitable for requirement associated with an educational asset. Materials characteristics and properties must be considered before selecting any flooring material or any asset (during decision making process).

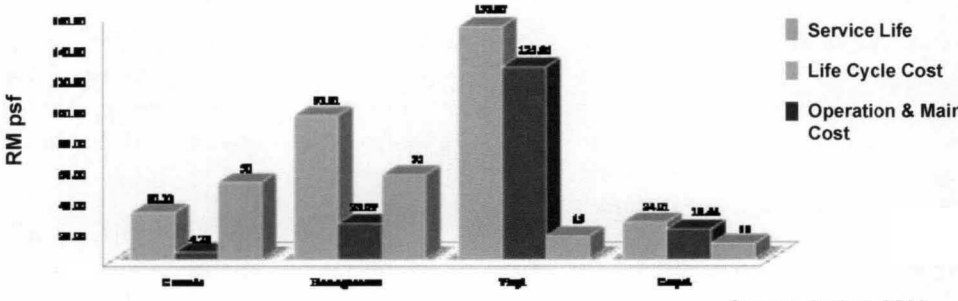
This case study also illustrates the importance of LCCA approach to the economic evaluation of real estate. In the foregoing case, not only is the initial capital investment considered but annual operating and maintenance cost for each alternative as well. The LCCA approach typically ensures a fair impartial treatment of all cost associated with economic alternatives.

After examination of the LCCA results, the initial hypothesis is confirmed; the most



Source: Author, 2009

Figure 6: Total O&M vs. LCC for Ceramic and Carpet



Source: Author, 2009

Figure 7: Increasing Service Life Versus LCC and O&M Cost

economical material was not necessarily the one with the lowest capital cost. Within an increasingly competitive global economy that enforces the maximising of cost saving with subsequent profit increases, successful organizations have demonstrated an understanding and commitment to two key issues that have been identified (Latino, 2002) which are increased productivity and growth.

It is proposed that both of these objectives can be achieved if new projects are identified and executed while simultaneously focusing on optimising the value from assets over the life cycle of assets.

For example, ceramic was the alternative with the lowest initial cost (RM1.87 psf) but was rank number two (2) based on the NPW value of RM 30.22 for a 60 building service life. Vinyl, which is the material with higher values of life cycle cost (RM 140.07), is also the one with the highest value for operation and maintenance cost of RM 12.00 psf.

Based on this research, it can be concluded that not all low initial cost alternatives will have a high life cycle cost, neither a high initial cost will guarantee a low life cycle cost. There must be a balance among the initial cost, the service life, and the O&M cost that allows for flooring alternatives that are within the budget limits of a property and asset's maintenance program.

This can only be achieved with contentious knowledge of the different alternatives for flooring and their specific characteristics

and maintenance requirements. From this study, a direct correlation between initial cost and the resulting NPW values was not found. However for both, flooring alternatives, correlations were found between cost of operations and maintenance and the resulting life cycle cost. It was clearly demonstrated that in most of the cases the benefits of selecting alternatives with low initial cost are overshadowed by the projected cost for the proper maintenance of the asset.

A low life cycle cost material may not be suitable for the requirements associated with an educational asset. Materials characteristics and properties must be considered before selecting any flooring material. Property and asset managers' experience and knowledge is needed to properly evaluate the most effective alternatives taking into consideration not just a low LCC but also to ensure the proper functionality of a building. Life cycle cost quantitative results should only be used as partial indicators and not a final decisive tool for the selection of interior flooring surfaces.

Recommendation for Future Research

The observations of the research actually bring a few ideas that may be; the future researcher can examine this analysis to the other assets either from the public sectors or private sectors. Besides that, this present research only based to the zero (0) discounted rate, so that, the future researcher may examine them into the materials and institution which provide some amount in the property and asset maintenance to their institution funding and budgets. Moreover, work out for the different way of materials, location, purposes of the analysis will help the new result especially in appreciating the functions of LCCA.

The LCCA model must be further tested with the universities or public sector to determine if the holistic approach does overcome the disadvantages that cause the maintenance models not to address PAM adequately in the acquisition phase of assets. Also in this present from the LCCA focuses on the total maintenance costs only. Additional aspect of corporate sustainability must be considered in terms of asset performance (Labuschagne et al, 2004) and the analysis must be revised accordingly.

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