SIGNIFICANT FACTORS INFLUENCING OPERATIONAL AND MAINTENANCE (O&M) COSTS OF COMMERCIAL BUILDINGS

Devindi Geekiyanage* and Thanuja Ramachandra

Department of Building Economics, University of Moratuwa, Sri Lanka

ABSTRACT

Usually, the costs incurred during the operational phase of a building are much greater than the initial construction cost. Amongst, the running cost of a typical commercial building varies between 70-80% of its total LCC depending on its determinants. However, the significance of those determinants could vary with building function, characteristics of location and economy where it is based. This paper, therefore, investigates the significance of factors influencing the running cost of commercial buildings in Sri Lanka. A questionnaire survey administered to a sample of 125 industry professionals who have more than 10 years of experience in building O&M indicates that O&M costs of a commercial building are influenced by 08 major determinants including building characteristics (BC), maintenance factors (MTF), managerial factors (MNF), environmental factors (EF), political factors (PF), tenant factors (TF), design and & construction defects (DCD), and social factors (SF). The relative significance index (RSI) analysis performed ranked EF as the top determinant influencing both operations and maintenance costs of commercial buildings with an RSI of 0.963 and 0.996 respectively. Further, all the respondents are of the view that building function, occupancy, and building services have a highly significant influence on operations costs whereas natural deterioration, failure to identify the true cause of defect, lack of preventive maintenance, and budget constraints are foremost factors influencing the maintenance costs. The impact of most of the sub-factors except very few namely, building function, age, and location on O&M costs can be controlled up to a greater extent. Thus, early consideration of these factors during the building design and construction will result in reduction of unnecessary costs to be incurred during the operational phase of a building.

Keywords: *Commercial Buildings; Correlation; Determinants; O&M Costs; Relative Significance Index.*

1. INTRODUCTION

Life Cycle Cost (LCC) of a typical building includes capital cost, occupancy and maintenance costs (utility, administrative, building services, replacement costs), and disposal cost. It is observed that the cost incurred during the operational phase of a building project is much greater than its construction or acquisition cost (Flanagan & Jewel, 2008). Most recently, Goh and Sun (2015) found that commercial buildings spend higher running cost than residential, institutional, and industrial buildings. In Wang, Wei and Sun (2014) study, commercial buildings were in the first place with running cost accounting for 70% of the total life-cycle cost.

The running cost of a building could be basically divided into two such as building operational cost and building maintenance cost. This significant growth in operations and maintenance (O&M) costs of buildings are affected by a wide range of factors and the impact of each parameter on the O&M costs vary depending on the building function, geographical characteristics and economy, where the building is located (Ali, 2009). Further, many researchers concluded that these factors have a significant influence on the O&M costs of buildings in developing countries (Kerama 2013; Olayinka and Babatunde 2015; Waziri 2016). Despite, very little attention has been paid to factors affecting O&M costs of commercial buildings, especially, which based in tropics. Therefore, this research investigates the significance of factors influencing the O&M costs of commercial buildings in Sri Lankan tropical climate.

*Corresponding Author: E-mail - d.geekiyanage22@gmail.com

2. FACTORS INFLUENCING THE OPERATIONAL AND MAINTENANCE COST OF BUILDINGS

The literature provides a thorough account of factors affecting the O&M costs of different types of built facilities such as housing, apartments, public buildings, commercial buildings and educational institutions based in different climatic and economic conditions. Accordingly, Ungar (2003) reported 05 factors affecting the operating cost of federal buildings including security requirements, budget constraints, geographical location of buildings, government mandates, and failure to adequately maintain buildings.

Referring to the maintenance cost, most of the investigations carried out are related to developing countries, especially for Nigeria, Malaysia and Kenya due to less attention and budget allocations for building maintenance work (Kerama 2013). For instance, Olayinka and Babatunde (2015) have carried out a study on factors affecting housing maintenance cost in Nigeria and found 20 factors. Out of 20 factors, design and proper workmanship, material specifications, construction supervision, detailing of working drawings, and cash flow analysis have ranked as top 05 factors influencing the housing maintenance cost. Most recently, Waziri (2016) concluded that defective construction materials, poor supervision, defects due to specifications, poor quality control on site, and architectural design defects are top 05 defects influencing the building maintenance cost in Nigeria. In addition, Ali (2009) opined that existing building condition, complaint received regarding building performance, building age, client's request, availability of funding, and Health & Safety (H&S) requirements affect the maintenance cost of buildings in Malaysia respectively. The study further revealed that first two variables have negative moderate correlations with maintenance performance of buildings that are 0.378 and 0.308 respectively. Except above, Kerama (2013) in the study of investigating factors affecting the housing maintenance management cost in Kenya identified 04 determinants including building characteristics, tenant factors, maintenance factors, and political factors. Subsequently, with regard to the commercial building based in Nigeria, Omari (2015) classified these factors into 05 categories such as technical, environmental, management, financial, and social. Besides, El-haram and Horner (2002) study carried out in Scotland divided factors affecting maintenance cost of buildings into 05 groups of variables namely, building characteristics, tenant factors, maintenance factors, political factors, and other factors. Authors further concluded that except building characteristics, high expectation of tenants, budget constraints, misuse of property, right to policy and inability to gain access to the property are key factors contributing to the housing maintenance cost in Scotland. In line with El-haram and Horner (2002), and Ali (2009), Faremi et al. (2015) ranked those factors according to its impact on maintenance cost of tertiary institutions in Nigeria. From the analysis, the age, size of the building, vandalism by users, faulty design and poor incorporation of building services result in dominant factors influencing the cost of maintenance in institutional buildings. Moreover, Ofori1 et al. (2015) have revealed 15 factors influencing the decisions to carry out maintenance works. Amongst, the misuse of building after completion of the construction, faulty design, unavailability of skilled labour, poor financial support for maintenance work, and not using preventive maintenance are the dominant factors influencing the maintenance of housing units in Ghana.

Apart from aforementioned studies, which investigated the factors influencing operational cost and maintenance cost of buildings separately, Perera et al. (2016) concluded that building characteristics, tenant factors, maintenance factors, regulatory and economic factors, and few other factors (Refer Table 1) are highly contributing to the O&M costs of condominiums in Sri Lanka.

Based on the foregoing review, factors influencing the operational cost of buildings can be discussed under 04 major determinants including building characteristics, maintenance factors, managerial factors, and political factors/regulatory requirements while an extensive set of 08 determinants inclusive of environmental factors, tenant factors, design and construction defects, and social factors, affect the cost of maintenance in buildings. Each determinant mentioned above has a range of sub-factors, which contribute to the growing costs of O&M in buildings as illustrated in Table 1.

Despite having enough literature on factors affecting the O&M costs of buildings, none of the studies focused on factors affecting the O&M costs of commercial buildings based in tropical climates particularly, in Sri Lanka. Considering the unique characteristics of building O&M, it is vital to identify the factors affecting these costs individually. For instance, building age has an influential impact on building maintenance cost, where no impact on operational cost (Faremi et al., 2015).

Table 1: Review of Factors Influencing O&M Costs of Buildings

Determinants and Sub-factors	Sources									
	Operational cost	Maintenance cost								O&M costs
	1	2	3	4	5	6	7	8	9	10
Building Characteristics (BC)										
1. Function		X	X							
2. Location	X									X
3. Building age		X	X	X	X	X	X			X
4. Building size		X	X		X		X			X
5. Building height		X	X			X	X			X
6. Type of structure		X	X			X	X			
7. Building materials and components		X	X		X	X	X	X	X	X
8. Building services					X		X			X
9. Finishes		X	X							X
Maintenance Factors (MTF)										
1. Failure to identify the true cause of defect	X					X				
2. Lack of preventive maintenance	X				X			X		
3. Poor workmanship	X	X	X		X		X			X
4. Faulty maintenance	X				X	X				
5. Low concern to future maintenance	X				X	X		X		
6. Failure to execute maintenance at the right time	X	X	X		X					X
Managerial Factors (MNF)										
1. Budget Constraints	X	X	X	X	X	X	X	X		X
2. Lack of building maintenance manuals, standards and specifications					X	X		X	X	
3. Poor quality of spare parts and materials		X	X		X	X	X			X
4. Unavailability of the required spare parts, tools and materials						X				
5. Poor financial control when executing maintenance			X		X	X	X			X
6. Poor or lack of training		X	X		X	X	X			X
7. Poor management by maintenance units		X	X			X	X			X
8. Unqualified and unavailability of maintenance contractors						X		X	X	
9. Unavailability of skilled and educated labours		X				X		X	X	
10. Failure reporting procedure			X		X					X
Design and Construction Defects (DCD)										
1. Poor supervision									X	
2. Architectural design defects					X	X		X	X	X
3. Poor quality control on site					X	X			X	
4. Defective construction materials									X	
5. Poor structural design					X	X		X	X	X
6. Lack of proper reinforcement in concrete									X	
7. Site defects						X		X	X	
Tenant Factors (TF)										
1. Vandalism by tenants		X	X		X	X	X			X

2.	Misuse of property		X		X	X	X		X
3.	Expectation of Tenants		X			X			X
4.	Ignorance about maintenance works				X		X		
5.	Accessibility to the property		X			X			X
	Environmental Factors (EF)								
1.	Natural deterioration								
2.	Harsh climatic conditions				X				X
	Political Factors (PF)								
1.	Changes in legislation (New H&S regulations)	X	X	X		X			X
2.	Changes in O&M standards	X							X
3.	Price inflation	X							X
4.	Changes in taxes and utility tariffs	X							X
	Social Factors (SF)								
1.	Cultural practices				X				
2.	Third-party vandalism		X	X					X

(Source: Adapted from 1-Ungar 2003; 2-Olayinka and Babatunde 2015; 3-El-haram and Horner 2002; 4-Ali 2009; 5-Faremi et al. 2015; 6-Omari 2015; 7-Kerama 2013; 8-Ofori1 et al. 2015; 9-Waziri 2016; 10- Perera et al. 2016)

3. RESEARCH METHODS

A preliminary survey was conducted among six subject experts who have more than 20 years of working experience to confirm the determinants identified through literature review and to develop the conceptual framework for factors influencing O&M costs of buildings as illustrated in Figure 1. Accordingly, 08 determinants together with 48 sub-factors were identified. Finally, a questionnaire survey was carried out among 125 industry professionals who have more than 10 years of experience in building operations and maintenance. The respondents were asked to indicate the extent to which that variables influence the operational cost (24 sub-factors) and maintenance cost (46 sub-factors) of commercial buildings in Sri Lanka, based on a five-point scale where, 1-Highly insignificant, 2-Insignificant, 3-Neither, 4-Significant and 5-Highly significant. A summary profile of survey respondents is presented in Table 2.

Table 2: The Profile of Survey Respondents

Profession	**Designations**	**Number of respondents**		**Work experience**	**Number of respondents**	
		No.	**%**		**No.**	**%**
Engineering	Chief Engineer (8), Facility Engineer (1), Electrical Engineer (17), Supervisors (9)	35	28	Less than 10 yrs.	29	23
Management	Mgr. Admin (8), Facility Mgr. (12), Mgr. Operations (32), Maintenance Managers (28), Service Managers (10)	90	72	10-20 yrs.	77	62
				More than 20 yrs.	19	15
	Total	125	100	**Total**	125	100

As shown in Table 2, most of the respondents are managers (72%) while 35% of the respondents are engineers. Very importantly, all the respondents have working experience in the field of building O&M in commercial buildings in Sri Lanka and the majority (62%) have 10 to 20 years of experience.

For data analysis, initially, a bivariate correlation analysis was conducted to explore the inter-correlation between the determinants of running cost in commercial buildings. The results were presented using the Spearman's correlation coefficient as it is the ideal method to interpret the correlations between ordinal variables, i.e. Likert scale data (Göb et al., 2007). At last, the determinants of O&M costs were prioritized using the Relative Significance Index (RSI) as other researchers such as El-Haram and Horner (2002) and Ali et al. (2010) who had done similar studies have adopted RSI to rank factors. RSI or weight is a type of relative importance analyses, which best fits the purpose of this study. According to Johnson and LeBreton (2004),

RSI aids in finding the contribution a particular variable makes to the prediction of a criterion variable both by itself and in combination with other predictor variables. The RSI can be shown in the form of;

$$RII = (\sum W)/(A * N) \quad \text{Eq. (01)}$$

where, W - weighting is given to each statement by the respondents and ranges from 1 to 5; A - higher response integer (5); and N - total number of respondents.

4. RESEARCH FINDINGS AND DISCUSSION

4.1. FINDINGS OF THE PRELIMINARY SURVEY

The preliminary survey was conducted among 06 subject experts in order to broaden the scope of determinants to ensure the assessment of O&M costs of commercial buildings fits with the local context. Accordingly, Table 1 developed with the aid of literature findings is modified by altering existing sub-factors and adding new sub-factors as per the expert opinions. All industry experts accepted all the determinants stated are as key variables contributing to the growing O&M costs of commercial buildings in Sri Lanka and they further elaborate the importance of identifying factors affecting building operational cost and building maintenance cost individually.

Accordingly, a conceptual framework for factors influencing the O&M costs of buildings that illustrated in Figure 1 is developed following the important suggestions made by the survey of experts along with the information obtained through the literature review.

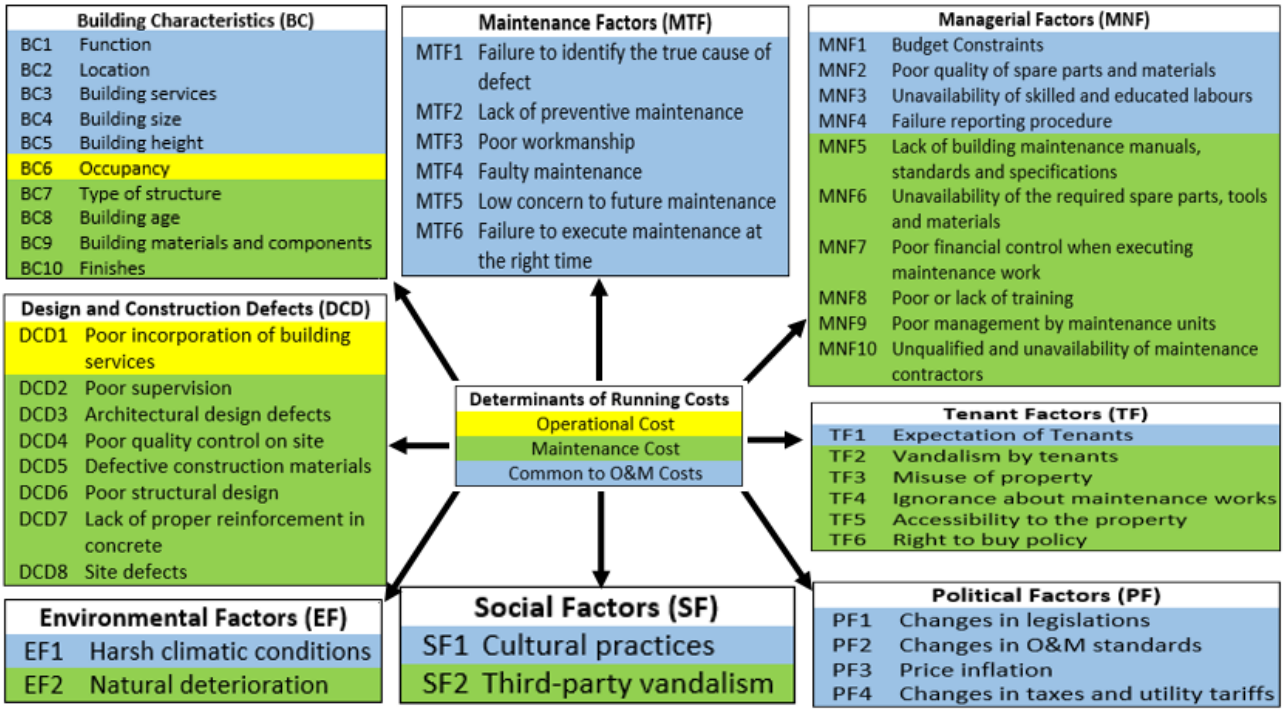

Figure 1: The Conceptual Frameworks for Factors Influencing O&M Costs of Buildings

As shown in the conceptual framework, operational cost of a building is influenced by 08 determinants together with 24 sub-factors, whereas the maintenance cost is affected by the same set of determinants having an extensive set of sub-factors, which is 46. Referring to the operational cost factors, experts highlighted few other variables including the number of occupants, building services, size, height, and function under the building characteristics. In addition, 04 experts elaborate that not only the maintenance cost but also the operational cost of a building is influenced by the poor quality of materials and components, unavailability of skilled and educated building operational staff, and inconsistency of failure reporting procedure, which stated under the managerial factors. Further, the poor incorporation of building services is added to the design and construction defects since it has a significant influence on utility cost of a building. Moreover, all the experts are of the view that expectation of tenants tends to fluctuate the operational cost of a building. For example, the comfort level of a person can be varied from another person thus, the required level of air conditioning,

ventilation and lighting may vary incurring severe changes to utility cost consequently, the operational cost. In addition, according to experts, harsh climatic conditions influence the operational cost of a building, especially in high temperature and humid levels, and rainy seasons due to environmental changes. Finally, cultural practices have been identified by 04 experts as a variable influencing the operational cost due to the impact of personal behaviour and clothing etc. However, none of the experts opined new variables to the maintenance cost factors thus, approved the sub-factors found through the literature as it is.

4.2. THE RELATIONSHIP BETWEEN DETERMINANTS OF O&M COSTS OF COMMERCIAL BUILDINGS

In the second stage of analysis, the mean values of determinants were subjected to a correlation analysis in order to explore the relationship between these determinants. The results obtained from the correlation analysis are presented in Table 3.

Table 3: The Correlation of Determinants of O&M Costs in Commercial Buildings

Determinant	Spearman's Correlation Coefficient (The Coefficient of Determination)															
	Operational Cost								Maintenance Cost							
	BC	MTF	MNF	DCD	TF	EF	PF	SF	BC	MTF	MNF	DCD	TF	EF	PF	SF
BC	1.000								1.000							
MTF	0.850** (92%)	1.000							0.047	1.000						
MNF	0.816** (90%)	0.787** (89%)	1.000						0.096	0.304** (55%)	1.000					
DCD	0.372** (61%)	0.224* (47%)	0.190* (44%)	1.000					-0.195* (44%)	0.047	0.142	1.000				
TF	0.372** (61%)	0.224* (47%)	0.190* (44%)	1.000** (100%)	1.000				0.131	0.101	0.037	0.034	1.000			
EF	0.057	0.127	0.138	-0.074	-0.074	1.000			0.136	0.077	0.253** (50%)	-0.020	-0.039	1.000		
PF	-0.091	-0.039	-0.103	-0.016	-0.016	0.000	1.000		-0.024	0.014	0.324** (57%)	-0.002	0.001	0.084	1.000	
SF	0.372** (61%)	0.224* (47%)	0.190* (44%)	1.000** (100%)	1.000** (100%)	-0.074	-0.016	1.000	-0.052	0.253** (50%)	0.354** (59%)	0.057	0.016	0.267** (52%)	0.043	1.000

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

According to the Spearman's correlation coefficients and the significance of correlations at 5% and 1% confidence levels, there are 15 statistically significant and positive correlations including 6 strong, 3 moderate, and 6 weak correlations among the determinants of operational cost in commercial buildings. The analysis further revealed 3 positive moderate correlations, 3 positive weak correlations, and 1 negative weak correlation between the determinants of maintenance cost in commercial buildings. Accordingly, determinants having strong and moderate correlations are discussed in more detail below.

Positive strong correlations

There are 6 positive strong correlations among the determinants of operational cost in commercial buildings. Three out of 6 correlations have resulted in a correlation of 1.000** and they are design and construction defects with tenant factors and social factors, and tenant factors with social factors. This indicates that these variables are 100% intercorrelated with each other thus, 100% of the mean value of one determinant can be explained by the other correlated determinant. Here, the impact of design and construction defects towards the operational cost of a commercial building could be totally controlled by either tenant factors or social factors or vice versa. Further, the behaviour of tenant factors can be 100% predicted by the behaviour of social factors. For example, if the building is designed and constructed as per the expectation of tenants, it could mitigate the impact of cultural practices on operational cost. However, most of the experts in the field of statistical analysis are of the view that these statistics do not reflect the exact behaviour of variables thus, cannot expect a 100% intercorrelation between covariables in practice. In addition, building characteristics has positive strong inter-correlation with maintenance factors (0.850**), and managerial factors (0.816**) under operational cost category. According to the determination of coefficients (R2), 72% and 67% of the mean value of building characteristics can be expressed by maintenance factors and managerial factors respectively or vice versa. Moreover, the maintenance factors and managerial factors are positively and strongly correlated (0.787**) with each other indicating that there is a direct influence in-between these two variables. For example, if it is

able to reduce the impact of managerial factors such as the use of poor quality spare parts and number of unskilled labours by providing required training, poor workmanship, lack of preventive maintenance, and faulty maintenance can be reduced, which come under the maintenance factors.

Positive moderate correlations

There are 3 positive moderate correlations among the determinants of operational cost in commercial buildings, which have resulted in R of 0.372** and R2 of 14%. They are building characteristic with design and construction defects, tenant factors, and social factors. Accordingly, only 14% of the mean impact of building characteristics upon the operational cost could be directly explained by either design and construction defects or tenant factors, or social factors. For instance, reduction of improper incorporation of building services could lead to reduce the utility cost incurred by building services and ultimately reduce the cost of building operations. Referring to the maintenance cost of commercial buildings, 3 positive moderate correlations have been found. The maintenance factors have an R equals to 0.304** with managerial factors and only 09% of the mean impact of maintenance factors could be predicted by managerial factors and vice versa. Furthermore, the managerial factors have a positive moderate correlation with political factors (0.354**) and social factors (0.324**). The ideal example to explain the relationship between managerial factors and political factors is the relationship between the proper use of manuals, standards and specifications for building maintenance, and changes introduced to building O&M standards by the government. If further described, the government and regulatory bodies issue updated building O&M standards time to time and building users need to comply with those standards while performing maintenance work of buildings consequently, reduce the impact of those two factors towards the maintenance cost of commercial buildings. Similarly, the behaviour of social factors such as third-party vandalism can be controlled by the proper management of maintenance units, which belongs to the managerial factors.

4.3. KEY FACTORS CONTRIBUTING TO THE O&M COSTS OF COMMERCIAL BUILDINGS

At last, an RSI analysis was conducted to explore the relative significance of factors influencing O&M costs of commercial buildings. Twenty-four sub-factors affecting the operational cost and 46 sub-factors affecting the maintenance cost of buildings, which found from the literature analysis and preliminary survey were approved by the respondents to the context of commercial buildings in different levels of significance. Accordingly, the relative significance of factors affecting operational cost and maintenance cost of commercial buildings are presented in Table 4 together with RSI value and stacked bar charts.

Table 4: The Relative Significance of Factors Affecting Operational & Maintenance Costs of Commercial Buildings

Table 4: The Relative Significance of Factors Affecting Operational & Maintenance Costs of Commercial Buildings

Operational Cost			Maintenance cost		
Code	**Sub-factor**	**RSI**	**Code**	**Sub-factor**	**RSI**
EF	**Environmental Factors**	**0.963**	**EF**	**Environmental Factors**	**0.996**
EF1	Harsh climatic conditions	0.963	EF2	Natural deterioration	1.000
PF	**Political Factors**	**0.962**	EF1	Harsh climatic conditions	0.992
PF3	Price inflation	0.974	**MTF**	**Maintenance Factors**	**0.988**
PF4	Changes in taxes and utility tariffs	0.965	MTF1	Failure to identify the true cause of defect	1.000
PF2	Changes in O&M standards	0.963	MTF4	Faulty maintenance	0.984
PF1	Health and safety regulations	0.944	MTF6	Failure to execute maintenance at the right time	0.978
BC	**Building Characteristics**	**0.960**	MTF2	Lack of preventive maintenance	1.000
BC1	Function	1.000	MTF3	Poor workmanship	0.984
BC6	Occupancy	1.000	MTF5	Low concern to future maintenance	0.982
BC3	Building services	1.000	**MNF**	**Managerial Factors**	**0.966**
BC4	Building size	0.971	MNF1	Budget constraints	1.000
BC5	Building height	0.942	MNF5	Lack of building maintenance manuals standards	0.995
BC2	Location	0.845	MNF2	Poor quality of spare parts and materials	0.989
DCD	**Design & Construction Defects**	**0.942**	MNF6	Unavailability of the required spare parts tools and materials	0.971
DCD1	Poor incorporation of building services	0.942	MNF7	Poor financial control when executing maintenance work	0.971
TF	**Tenant Factors**	**0.942**	MNF8	Poor or lack of training	0.968
TF1	Expectation of Tenants	0.942	MNF9	Poor management by maintenance units	0.957
SF	**Social Factors**	**0.942**	MNF10	Unqualified and unavailability of maintenance contractors	0.954
SF1	Cultural practices	0.942	MNF3	Unavailability of skilled and educated labours	0.928
MTF	**Maintenance Factors**	**0.852**	MNF4	Failure reporting	0.925
MTF4	Faulty maintenance	0.942	**DCD**	**Design & Construction Defects**	**0.920**
MTF2	Lack of preventive maintenance	0.922	DCD2	Poor supervision	0.974
MTF1	Failure to identify the true cause of defect	0.847	DCD3	Architectural design defects	0.971
MTF5	Low concern to future maintenance	0.845	DCD4	Poor quality control on site	0.946
MTF6	Failure to execute maintenance at the right time	0.840	DCD5	Defective construction materials	0.930
MTF3	Poor workmanship	0.713	DCD6	Poor structural design	0.918
MNF	**Managerial Factors**	**0.824**	DCD7	Lack of proper reinforcement	0.912
MNF3	Unavailability of skilled and educated labours	0.942	DCD8	Site defects	0.787
MNF2	Poor quality of spare parts and materials	0.845	**BC**	**Building Characteristics**	**0.891**
MNF4	Failure reporting	0.845	BC8	Building age	1.000
MNF1	Budget requirement	0.662	BC3	Building services	1.000
			BC4	Building size	0.973
			BC9	Building materials and components	0.957
			BC1	Function	0.942
			BC5	Building height	0.936
			BC7	Type of structure	0.915
			BC2	Location	0.842
			BC10	Finishes	0.453
			TF	**Tenant Factors**	**0.883**
			TF2	Vandalism by tenants	1.000

TF3	Misuse of property	1.000
TF1	Expectation of Tenants	1.000
TF4	Lack of understanding the importance of maintenance work	0.955
TF6	Existence of buy policy	0.595
TF5	Accessibility to the property	0.746
SF	**Social Factors**	**0.886**
SF2	Third party vandalism	0.948
SF1	Cultural practices	0.824
PF	**Political Factors**	**0.730**
PF4	Changes in taxes and utility tariffs	0.200
PF2	Changes in O&M standards	0.963
PF1	Health and safety regulations	0.944
PF3	Price inflation	0.814

As shown in Table 4, foremost determinants affecting operational costs are environmental factors (0.963), political factors (0.962), and building characteristics (0.960) respectively. Further, top 03 factors influencing the operational cost of commercial buildings are the function of buildings (1.00), the number of occupants (1.00), and building services (1.00), which gathered under the building characteristics. The function of a building refers to the core business inside the building. The operational cost of a building could vary depending on its function such as commercial, industry, educational and residential etc. As opined by experts during the preliminary survey, "it is apparent that the operational cost of a building may increase with the increase of occupants". For example, the energy required for space cooling and lighting is directly influenced by the number of occupants thus, increase the utility cost, which is a significant operational cost component. According to Ali et al. (2010), the maintenance cost of building services is relatively high as it covers 20-45% of the total building running cost. Next, political factors including price inflation (0.974), changes to taxes and utility tariffs (0.965), and changes in O&M standards 0.963 are key parameters of operational cost in commercial buildings. In Sri Lanka, several legislations and Acts have been introduced relating to the building operations and the implementation of those have become a key concern and legal requirement, particularly in commercial buildings. Few illustrations are as the National Environmental (Municipal Solid Waste) Regulations (No. 1 of 2009) and the Protection of The Rights of Persons with Disabilities Act (No. 28 of 1996). Further, the implementation of CIDA fire regulations is a mandatory requirement for all buildings over 30 meters. And also, the influence of new H&S regulations on building operational cost has been previously elaborated by Ungar (2003). Further, the harsh climatic conditions (0.963) influence the operational cost of commercial buildings. Changes in the climate vary the operational cost throughout the year due to human sensitive environmental changes. For example, the cost of air conditioning may increase with the increase of temperature levels compared to rainy seasons.

Referring to the maintenance cost of commercial buildings, environmental factors (0.996), maintenance factors (0.988), and managerial factors (0.966) are the top determinants respectively. Amongst all sub-factors, 09 including natural deterioration, failure to identify the true cause of defect, lack of preventive maintenance, budget constraints, building age, building services, vandalism by tenants, misuse of property, and expectation of tenants have been resulted with a RSI=1.00 indicating that all respondents are of the view that these factors have a highly significant impact on maintenance cost of commercial buildings. Deterioration of a building can occur either as natural or forced. Natural deterioration defines as physical wear that occurs even though the building is used and maintained properly. It could be occurring due to various reasons basically, continuous usage of building and exposure to the normal environment. The speed or frequency of natural deterioration can be reduced only by way of enhancing the inherent reliability of building. Further, if it is failed to detect the true cause of the defect that could be ended up with unnecessary corrective actions incurring an unnecessary cost for maintenance, where the defect still remains for seeking required maintenance. In addition, not practicing strategic maintenance methods such as preventive and predictive lead to excessive maintenance work and increase the breakdown time and labour cost, which ultimately result in decreased productivity. As Sri Lanka is a country, which has a developing economy, the insufficient fund has become a key issue in many aspects. This has found most commonly in other developing countries such as Nigeria, Kenya and Malaysia due to less attention and budget allocations for building maintenance work (Olayinka and Babatunde, 2015; Omari, 2015; Kerama, 2013). It is apparent that any property deteriorates as it is aged thus, required necessary

maintenance to upgrade its quality in many aspects, i.e. for buildings, in performance, safety and market value. The positive relationship between building age and maintenance cost has been previously confirmed by Faremi et al. (2015). Moreover, building services, which gives the life to a building structure have its immense impact on building maintenance. For example, a building cannot be converted to a place where humans can be occupied, i.e. office, at least without key building services such as plumbing, electricity, telecommunication, housekeeping and security etc. Thus, the proper maintenance of these building services directly affects the performance of the building and smooth functioning of the building operations although it incurs a significant share of the total building maintenance cost. At last, the demand made by tenants for a better lifestyle or a living environment is rapidly increasing. This phenomenon has led to the need for maintenance and a corresponding rise in O&M costs (Perera et al., 2016).

5. CONCLUSIONS AND RECOMMENDATIONS

Although both operational cost and maintenance cost belongs to the running cost, factors affecting the costs of building O&M could be varied. Initially, a conceptual framework was developed for the factors influencing O&M costs of buildings and it reveals that the O&M costs of commercial buildings are influenced by 08 determinants namely, building characteristics, maintenance factors, managerial factors, design and construction defects, tenant factors, environmental factors, political factors, and social factors. Further, there are statistically significant inter-correlations between most of the determinants thus, the reduction or elimination of bad impacts of one particular determinant can lead to control the severe influence of the correlated variable on building operational or maintenance cost. Further, giving attention to the relative significance of factors contributing to the building O&M costs, environmental factors, maintenance factors, managerial factors, political factors, and building characteristics may cause a significant impact on O&M costs of commercial buildings in tropics. With reference to the data analysis, most of these factors are controllable to a greater extent except to a very few such as building age, function and location. For example, building characteristics have a significant impact upon both operational cost and maintenance cost and optimization of these characteristics at the pre-construction stage of buildings can lead to minimizing the costs to be incurred during the operational phase of buildings. Finally, it is necessary to conclude that O&M costs have to be given proper consideration at the initial stages of the project itself.

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