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Determinants of operational and maintenance costs of condominiums

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Abstract

It is important to determine the factors which affect the operational and maintenance costs of condominiums in order to minimize them. Furthermore this would assist the building managers in preparing realistic maintenance budgets in respect of each operational and maintenance activities in the appropriate time. Therefore, this study proposes a framework to control the operational and maintenance costs of condominiums built in Sri Lanka by identifying their determinants.

A preliminary survey was initially carried out among six experienced professionals from the industry and it was followed by distributing 35 questionnaires also among professionals from the industry. The Analytical Hierarchical Process and the Relative Importance Index were used to analyze the data gathered.

The findings of the study show that the dominant factors which affect the operational and maintenance costs of condominiums were 'Expectations of Tenants', 'Building Services' and 'Building Finishes'. It was found that 'Including maintenance standards in the Tenancy Agreement' and 'Finding means of increasing service efficiency' are the main important actions that control the seven determinants that have been identified as the most important.

The framework developed through this research enables the identification of the determinants which govern the maintenance and operational costs of condominiums and the actions that control them.

Keywords: Operating Costs, Building Maintenance, Controls.

Introduction to condominiums

Large cities are being increasingly built in Asia, where scarcity of land resulting from rapid urbanisation compels residential development to take up a high-rise and high-density form (Yip and Forrest, 2002). Further, the increasing popularity of owner occupation in the last couple of decades has made condominiums the most prevalent and popular form of residential development (Yip et al., 2007). The word 'Condominium' is a combination of two Latin words which identify two distinct features of condominium living that is individuality and commonality (Edirimane, 2006). According to Edirimane (2006), condominiums provide a more secure and safer environment for their occupants compared to other types of dwellings and this has become the prime reason for many people in Sri Lanka to move into condominium housing.

The Section 2 of the Apartment Ownership Act No.11 of 1999 defines a Condominium as a property having land with a building or buildings of more than one storey and having more than one unit residential or non-residential accommodation. The Common Amenities Board Act No. 24 of 2003 has classified condominiums in Sri Lanka under four categories, i.e residential, commercial, industrial, and mixed-use. Residential

condominiums which are in high demand in Sri Lanka, could again be subdivided in to four categories, viz., super luxury, luxury, semi luxury, or utility (Wijeyweere, 2004 cited Sampath, 2011).

Studies on condominiums have become important as they play a vital role in the Sri Lankan economy (Senaratne et al., 2006). Further, a study by Ariyawansa (2007) has shown that some condominium development work in Sri Lanka; such as those related to Havelock City, Royal Park, Crescat and Kings Court have triggered investigations in to such work. Ariyawansa (2007, p.11) has therefore stated that in respect of available market opportunities in the Colombo metropolitan area, condominium development related researches can be quite useful. However as far as their running costs are concerned, despite their significance, condominiums have now become the most affected among the different types of real estate development. (Olubodun and Mole, 1999) This is because of the emphasis placed by both the occupants and maintenance teams of condominiums on the quality and the optimum performance of their health, safety and environmental related facilities instead of their Operational and Maintenance (O & M) costs. (Ali et al., 2010; Emma and Syahrul, 2009; Williams, 1996). If the running costs of condominiums are to be reduced, there should be more focus on their operational and maintenance related features. Therefore, as pointed out by Ali et al. (2010), it will be important to identify the determinants affecting O & M costs of condominiums as well as the steps that can be taken to control and minimize their effects.

In this research, super luxury and luxury condominiums coming under the category of residential condominiums for which there is currently a high demand and supply, are analyzed to identify the dominant factors affecting the maintenance and operational costs of their modern facilities.

O & M Costs of condominiums: Their Determinants and Controlling Actions

Buildings start aging from the time they are completed and put to use (Horner et al., 1997). It is necessary to maintain them properly if their effective and economic use is to be ensured (Simoes et al., 2011). Building operational activities are routine functions that are undertaken for hygienic, aesthetic and security purposes, and for the supply of utilities (Goodman, 2004) which, according to Sliteen et al., (2011), are necessary to keep the building in a habitable and usable condition. In the real estate industry, maintenance and operations are combined and called O & M since a facility cannot operate at its maximum efficiency without being properly maintained (Stoy and Kytzia, 2008).

Operational and maintenance work of a building is considered as a service that the landlord or the management company has to provide to its tenants (Lai et al., 2008). The scope of this work includes the activities required to keep the entire built environment as recorded in the organization's Real Property Inventory of facilities and their supporting infrastructure, including utility systems, parking lots, roads, drainage systems and grounds in a condition that meets their intended functions during their expected life cycles (Bardey et al., 2005).

According to Goodman (2004) and Eisenstadt (1972), the operational and maintenance cost components of condominiums include capital expenditure along with salaries, insurance fees, taxes, utility fees, management fees, administrative, marketing and contract service fees and repair/maintenance fees. Komonen (2002) has stated that operational and maintenance costs of the condominiums are the costs associated with their day-to-day repair and preventive and improvement work. They are related to the direct cost of items required for maintenance such as material, labour, plants and tools as well as to its indirect costs such as

management costs and administrative and overhead costs needed for the successful completion of the work (El-Haram and Horner, 2002). As a sum up of all these aspects Lai and Yik (2008) have identified O & M costs as a combination of four major cost components, namely, repair and maintenance cost, capital investment cost, administration and staff cost, and water and energy cost.

Identification of factors affecting O&M costs

The studies of Lai and Yik (2008) have identified factors affecting O & M costs under two headings: service quality and scale of work. However, according to researchers (O'Neill, 1974; Skinner, 1982;Neveset al., 2004; Wong, 2002; Shabha, 2003; Cheung and Kyle, 1996; Love and Irani, 2003; Khalid et al., 2006; Al-hammad et al., 1996; Pascual et al., 2008; Olubodun, 2001; Lee and Scott, 2009; Ali, 2009; Yip, 2001; Olubodun and Mole, 1999; Al-Arjani, 1995; Wordsworth, 2001; Thompson, 1994), there are several factors that affect O & M costs of condominiums. In summary, determinants of O&M costs can widely be discussed under five broad categories, that is, building characteristics, maintenance factors, tenant factors, regulatory and economic factors and other factors (Refer Figure 1). Further based on the literature findings, the researcher has further summarized the relevant sub factors of each category as illustrated in Figure 1.

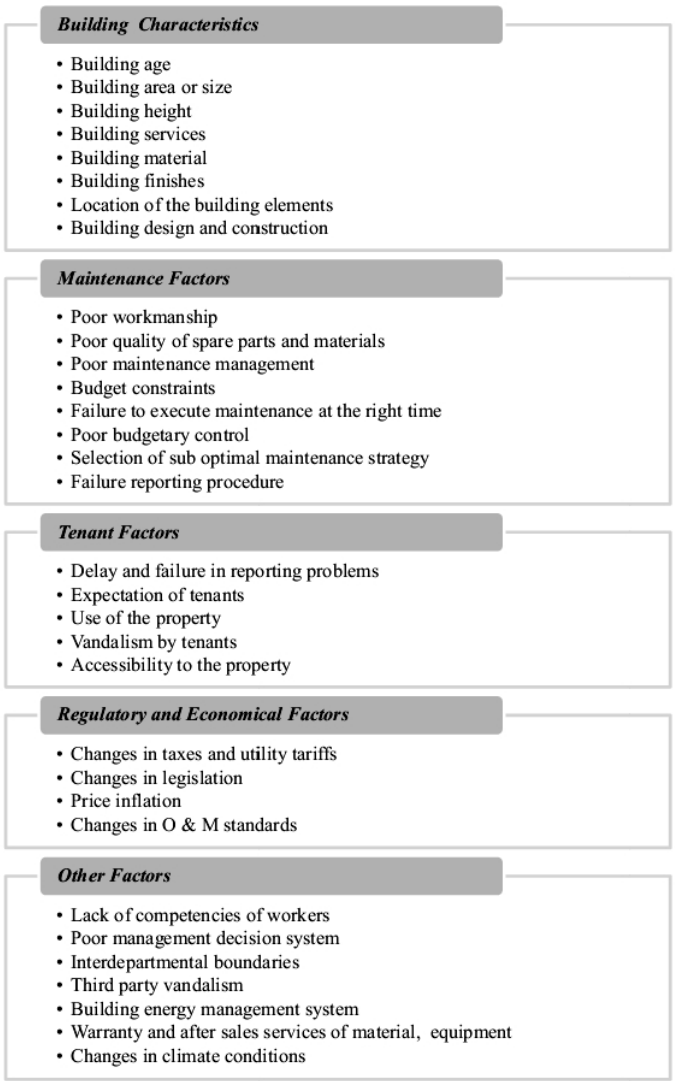

Figure 1: Conceptual Framework of the Determinants of Condominiums' O & M Costs

According to the literature, building characteristics like building age, area, size, height, services, material used, finishes, and design and construction are the main considerations for O&M costs. Further there were certain maintenance factors such as workmanship, spare parts and material and selection of sub optimal maintenance strategy which are considered as factors affection O&M costs (Olubodun and Mole, 1999; Al-Arjani, 1995).

In the perspective of tenants, there can be certain factors which govern the O&M cost. These are delay and failure reporting problems, standard of usage of the property and accessibility to the property can be considered as tenant factors (Neveset al., 2004; Wong, 2002). This aspect clearly shows that O&M costs are dependent on many stakeholders and not just the management. Further, regulatory factors such as changes in taxes and utility tariffs and changes in legislation also directly aft the O&M costs.

Finally, there are many factors, which are general in nature, but yet have a direct impact on the O&M costs. Poor or lack of training', poor management decisions systems, inter departmental boundaries, third party vandalism and building energy management system are few of those which are other factors. All these are summarized and presented in Figure 1 below after the certain modifications with the details developed from the preliminary survey. Details of the preliminary survey and modifications are illustrated later on in this paper.

Identification of corresponding controlling factors

Ali et al. (2010) have pointed out, the identification of the corresponding controlling actions for the determinants is the best way to minimize the impact of these determinants, which could ultimately bring about a reduction in the O & M costs of condominiums.

Among the ordinary controlling actions of the determinants identified in various studies are: the participation of tenants in the condominium management, availability of property operating manuals, effective maintenance management, allocation of a balanced budget for each maintenance task, and employment of workers with acceptable qualifications (Rydell, 1970; Eisenstadt, 1972; El-Haram and Horner, 2002; Goodman, 2004; Dhillon and Liu, 2006; Lai and Yik, 2008; Ali et al., 2010). Based on the literature, for each sub-factor, controlling actions are identified.

Further, based on these researches, 92 controlling actions were also identified for each sub factor of a determinant of O&M costs (Refer Table 1).

Table 1: Controlling Factors
Developed from : Rydell, 1970; Eisenstadt, 1972; El-Haram and Horner, 2002; Goodman, 2004; Dhillon and Liu, 2006; Lai and Yik, 2008; Ali *et al.*, 2010

	Controlling Actions	
Building Characteristics	**Budget constraints**	Plan maintenance with an analysis of taxes and utility tariff changes
Building age	Ensure and enforce that all tenants pay maintenance fee on time	**Changes in legislations**
Select the most suitable maintenance type and frequency	Maintain required level of sinking funds	Keep maintenance work flexible to accommodate legislation changes
Refurbish condominium building	Increase awareness on the importance of the appropriate furnishing of money for maintenance works	Prepare provisions for legislations changes
Upgrade services	**Failure to execute the maintenance at the right time**	Keep in touch with required legal bodies
Building area or size	Fix the optimum maintenance schedule, supervision and action plan	**Price inflation**
Select the most suitable maintenance type and frequency	Manage an effective supply chain	Prepare provisions for price changes
Plan maintenance works to gain the benefit of economies of scale	Motivate maintenance staff about the application of best practice	Maintain proper contract documentation regarding prices of supplies
Upgrade services	**Poor budgetary control**	Keep maintenance work flexible to accommodate changes
Building height	Ensure proper flow of information regarding budgetary requirements	**Changes in operational and maintenance standards**
Introduce maintenance free modern systems	Allocate balanced budgets in every maintenance task	Keep maintenance work flexible to accommodate changes
Introduce new maintenance technologies for work at a height	Practice appropriate budgeting techniques	
Select the most suitable maintenance type and frequency	**Selection of sub-optimal maintenance strategy**	Undertake proper analysis prior to launching standard changes
Quality level and number of building services	Timely analysis and modifications on maintenance strategy	Prepare provisions for standard changes
Find means of increasing services' efficiency	Increase maintenance staff experiences on decision making	***Other Factors***
Employ appropriate building services	Develop continuous process for maintenance	**Lack of competencies of workers**
Select the most suitable maintenance type and frequency	**Poor failure reporting procedure**	Have proper man-power enrolment policy
Building material	Timely analysis and modifications in failure reporting procedure	Arrange required training programs
Try to adopt maintenance free material and finishes	Preparing a well-organized failure reporting procedure	Arrange frequent competency testing programs
Use durable material and finishes	Increasing awareness on failure reporting procedure	**Management decision system**
Use material and finishes which facilitate ease of maintenance	***Tenant Factors***	Enhance the flow of information for decision-making
Location of the building elements	**Vandalism by tenants**	Ensure participation of all concerned parties in decision-making
Try to place building elements in places where it leads to less maintenance requirements	Increasing awareness on condominium living style	Require mutual understanding of professional decision makers
Select the most suitable maintenance type and frequency	Increasing security system productivity	**Building energy management system**
Introduce the required maintenance tools, material, and equipment for various elements	Including the vandalism cost into the fee as a penalty	Motivate the best energy management practices
Building design and construction	**Delay and failure in reporting problems**	Integrate required energy management strategies
Design and construct buildings that facilitate ease of maintenance and future adaptability	Increase awareness on the impact of maintenance cost to the monthly fee	Improve awareness and knowledge of energy management among both tenants and the staff

Ensure the participation of maintenance professionals at initial stage	Active participation of tenants in condominium management work	**Interdepartmental boundaries**
Conduct proper initial requirements analysis	Educating tenants about reporting problems	Enroll multi-skilled professionals
Building finishes	**Expectations of tenants**	Enhance cooperation among interdepartmental works
Try to adopt maintenance free material and finishes	Include maintenance standards in tenancy agreement	Separate departmental works as much as possible
Use durable material and finishes	Tenant participation in condominium management works	**Third party vandalism**
Use material and finishes which facilitate ease of maintenance	Educate tenants on the impact of quality level for their monthly fee	Increase security system productivity
Maintenance Factors	**Accessibility to property**	Extend awareness of all external parties about condominium operations
Poor workmanship	Include maintenance standards in tenancy agreement	Proper legal actions for vandalism
Train maintenance staff properly on works	Increase awareness on the importance of building maintenance	**Warranty and after-sales services of material**
Arrange effective supervision at works	Negotiate with tenants	Maintain proper documentation of warranty and after-sales services
Select professionals in-house, outsource maintenance staff	**Use of the property**	Pay attention to warranty and after-sales services in the tender evaluation
Poor maintenance management	Introduce property operating manuals	Analyze market support for material and equipment
Enhance management staff knowledge on recent trends in maintenance management	Educate tenants	**Changes in climate conditions**
Balance in-house and outsource maintenance management	Provide financial incentives for proper use	Plan maintenance with a climate changes trend analysis
Select top professional decision makers	***Regulatory and Economic Factors***	Keep maintenance works flexible to accommodate weather changes
Poor quality of spare parts and materials	**Changes of taxes and utility tariffs**	Select the most suitable maintenance type and frequency to accommodate weather changes
Rearrange buying policy of the condominium	Prepare provisions for taxes and utility tariff changes	
Properly inspect materials before use	Keep maintenance work flexible to accommodate the change	

Research Methodology

The research used a literature survey, a preliminary survey, structured interviews and a questionnaire survey. The factors that affect condominium O & M costs were first identified through the literature survey and summarized. Then a preliminary survey (semi structured interviews) was conducted among six experts from the industry each of whom had more than 20 years of working experience. The preliminary survey was conducted in order to identify the determinants and to develop a conceptual model. Finally a questionnaire survey was carried out among 35 experts from the industry with whom structured interviews were conducted in order to identify the degree of significance of each of the determinants and the controlling actions related to each of the identified determinants.

The analytic part of the research was conducted using AHP (Analytical Hierarchy Process), a multi-criteria decision making tool and RII (Relative Important Index). The AHP tool was used because it could be used to simplify the complex interactions between the thirty-two determinant criteria of the research into simple pair-wise comparisons and since it is much better than the other available multi-criteria decision making tools. Since the development of the framework for the determinants and controlling actions of the O & M costs of condominiums heavily depend on subjective judgements, AHP was identified as the most suitable multi-criteria decision making tool in order to convert those subjective judgements into numerical data (Lam and Zhao, 1998; Cheng and Li, 2001; Day, 2002; Celik et al., 2007; Macharis et al., 2004; Zahir, 1999).

The determinants of O & M costs were prioritized according to the AHP technique while the prioritizing of controlling actions was done using RII as other researchers such as El-Haram and Horner (2002), Johnson (2000), Jeyamathan (2005), Wang et al. (2000), Thomas et al. (2003), and Ali et al. (2010) who had done similar studies have also adopted RII to rank factors.

Research Findings

Details of the Questionnaire Survey

Thirty-five questionnaires were distributed among well-experienced representatives of the condominium management industry who formed a fair sample of various professions involved with condominium management. As shown in Table 1, out of the 35 responses received 31 were found to be useful and valid for the analysis. The response rate was high (89%) probably due to the reason that all 35 questionnaires were hand delivered to the respondents with their consents obtained over the telephone and with formal appointments made.

Table 2: Respondents by Category in the Secondary Data Collection

Profession Category	Number of Respondents
Resident Manager	*10*
Chief Engineer	*06*
Maintenance Manager	*04*
Civil Engineer	*03*
Mechanical Engineer	*03*
Electrical Engineer	*03*
Facilities Manager	*02*
Total	***31***

Findings of Preliminary Survey

A model was developed from literature findings and the conceptual frame work outlined in Figure 1 was developed with the aid of the preliminary survey by modifying the model developed with literature. During the preliminary survey, this theoretical model was extended to form a conceptual framework by removing and altering several existing factors, adding new factors and broadening the scopes of the main factors to ensure the evaluation of the O & M costs of the condominiums in a broader context.

The sub factors identified from the literature review under the main factor 'building characteristics' were accepted by all the industry representatives as relevant and appropriate. However, to suit local perspectives, the sub factor, 'type of structure', was replaced with a new sub factor named 'location of the building elements'.

All seven sub factors which were identified from the literature review under 'maintenance factors' were strongly recommended by all the interviewees. 'Failure reporting procedure' was suggested as a new sub factor under this category and the sub factors 'delays and failures in reporting problems', 'expectations of tenants', 'use of the property', 'vandalism by tenants', and 'accessibility to property' were acknowledged by all the industry representatives as factors that should come under ' tenant factors', and in their view the sub factor 'tenant's complaints through different channels' was not applicable to local condominiums as at present.

The main category identified as 'political factors' through the literature was renamed as 'regulatory and economic factors' and two new sub factors , 'price inflation' and 'changes in O & M standards' were introduced in to it after the preliminary survey .

All industry representatives accepted most of the sub factors listed under the 'other factors' category but suggested the replacement of the sub factor 'poor or lack of training' with the sub factor named 'lack of competencies of workers'. Sub factors 'building energy management system' and 'warranty and after sales services' were added to the 'other factors' category. As the literature does not provide any provisions for the changes of climatic conditions, the suggestion to introduce a new sub factor under the heading 'other factors' to evaluate the impact of the changes of climate conditions to condominium O & M costs was accepted. The conceptual framework illustrated in Figure 1 is a result of these important suggestions made by the respondents along with the information obtained through the literature review.

Identification of Significant Determinants of Sri Lankan Condominiums' O & M Costs

Using a structured questionnaire, the respondents were asked to identify the degree of importance of the main categories identified through the preliminary survey. This exercise was extended also to the sub-factors under each main factor. Table 2 shows the ranking of the determinants based on their significance to the O & M costs of condominiums.

Table 3: Significance of Determinants to Condominiums' Operational and Maintenance Cost

Main Factors and Sub-Factors	Individual Significance	Ind. Rank	Overall Significance	Over. Rank
Building Characteristics			*0.3522*	*01*
Building services	0.1867	**01**	0.0657	**02**
Building finishes	0.1825	**02**	0.0643	**03**
Building age	0.1778	**03**	0.0626	**04**
Building area or size	0.1188	**04**	0.0418	**07**
Building material	0.1088	**05**	0.0383	**09**
Building height	0.0954	**06**	0.0336	**14**
Building design and construction	0.0796	**07**	0.0280	**18**
Location of the building elements	0.0505	**08**	0.0178	**24**
Maintenance Factors			*0.2244*	*03*
Execution of maintenance at right time	0.1621	**01**	0.0364	**11**
Budgetary constraints	0.1559	**02**	0.0350	**13**
Poor quality of spare parts and materials	0.1490	**03**	0.0334	**15**
Poor workmanship	0.1466	**04**	0.0329	**16**
Poor budgetary control	0.1341	**05**	0.0301	**17**
Poor maintenance management	0.0972	**06**	0.0218	**20**
Sub-optimal maintenance strategy	0.0905	**07**	0.0203	**22**
Failure reporting procedure	0.0646	**08**	0.0145	**27**
Tenant Factors			*0.2265*	*02*
Expectation of tenants	0.3111	**01**	0.0705	**01**
Use of the property	0.1987	**02**	0.0450	**05**
Accessibility to property	0.1979	**03**	0.0448	**06**
Delay and failure in reporting problems	0.1758	**04**	0.0398	**08**
Vandalism by tenants	0.1165	**05**	0.0264	**19**
Regulatory and EconomicFactors			*0.1147*	*04*
Price inflation	0.3215	**01**	0.0369	**10**
Changes in taxes and utility tariffs	0.3123	**02**	0.0358	**12**
Changes in M & O standards	0.1897	**03**	0.0218	**21**
Changes in legislation	0.1765	**04**	0.0203	**23**
Other Factors			*0.0822*	*05*
Building energy management system	0.2003	**01**	0.0165	**25**
Poor management decision system	0.1810	**02**	0.0149	**26**
Lack of competencies of workers	0.1581	**03**	0.0130	**28**
Warranty and after-sales services of material	0.1328	**04**	0.0109	**29**
Interdepartmental boundaries	0.1271	**05**	0.0104	**30**
Changes in climate conditions	0.1022	**06**	0.0084	**31**
Third party vandalism	0.0986	**07**	0.0081	**32**

Based on AHP calculations, the categories which have a significant effect on O&M costs were identified and their sub factors were also ranked. This is illustrated in Table 2. The individual rankings given in Table 2 relates to the ranking of sub factors under each main category.

Importance of sub factors

According to the overall significance level of the determinants of the O & M costs of condominiums (Table 2), 'expectation of tenants' has become the most important sub-factor with a 0.0705 relative determinant score. In fact, the demand made by tenants for a better life style or a living environment is rapidly increasing. This phenomenon has led to the need for maintenance and a corresponding rise in O & M costs. The second most important sub-factor is the 'building services' with a 0.0657 determinant score. According to Ali et al. (2010), the building services maintenance cost is relatively high as it covers 20 to 45 per cent of the total building running cost. This

statement is verified by its high determinant score of 0.0657.

'Building finishes' has been rated as the third most important sub-factor that controls the O & M costs of condominiums with a 0.0643 determinant score. This research finding confirms previous studies by Shabha (2003) who discusses how incompatible and poor building finishes can cause deterioration or defects in building components resulting in a high maintenance cost for repairing or replacing such components. The age of the building was the fourth ranked sub-factor affecting the control of O & M costs of condominiums. According to Horner et al.(1997), one of the essential elements that needs to be considered in the preparation of maintenance budgets is the age of the building since older buildings would invariable require additional maintenance work. The fourth position allocated to 'building age' in the framework with a 0.0626 determinant score level to support this view.

The fifth important sub-factor controlling the O & M costs of condominiums is the 'use of the property', which has scored (at 0.0450) almost the same relative determinant score as the fourth sub-factor with an insignificant deviation of only 0.0176. Horner et al. (2008) too identified 'use of the property' as a prominent determinant of condominium running costs due to the unavailability of property operating manuals and proper tenant education about the condominium living environment.

According to El-Haram and Horner (2002), the inability to gain access to the property due to privacy or cultural reasons is one of the major factors that affect condominium maintenance costs. In line with previous research findings, 'accessibility to property' has become the sixth most important sub-factor controlling condominium O & M costs with a 0.0448 relative determinant score.

With a 0.0030 difference from the sixth ranked sub-factor, 'building area or size' has become the seventh important sub-factor with a 0.0418 relative determinant score level. This seventh sub-factor is 0.0239 times more insignificant than the last sub-factor 'tenant expectations'. Thus, early response to building failure would be necessary in order to reduce maintenance costs. However early response to building defects or failure is not possible if there has been a delay and failure in reporting the problems. In accordance with the above outlined scheme in terms of importance, 'delay and failure in reporting problems' is the eighth sub-factor with a 0.0398 determinant score.

By scoring a 0.0383 determinant score level, 'building materials' has become the ninth important sub-factor. This result confirms the observation of Ali et al. (2010) that improper material selection over the life of a facility or a building component is one of the dominant factors affecting condominium O & M costs. 'Price inflation' ranks as the tenth important sub-factor in the investigation of the operational and maintenance costs of condominiums with a 0.0369 determinant score. Thus the sub-factors one to ten varies along a 0.0336 determinant score range. This emphasizes the near equal importance of all the ten sub-factors in the appraisal of condominium running costs. Further, the top 9 sub factors are categorized under the main two categories namely' building characteristics' and' tenant factors'.

Controlling Actions for Determinants of O&M costs

The controlling actions were identified through the literature survey and these controlling actions were prioritized in the secondary data collection. During the preliminary survey, the literature findings on controlling actions were upgraded by removing and altering the existing controlling actions, and by adding new controlling actions and broadening the scope

of the key controlling actions in order to control the O & M costs of condominiums in a logical manner as shown in table 3.

Prioritization of the Controlling Actions of the Determinants

The Relative Important Index (RII) method was mainly used in order to screen the controlling actions collected from the preliminary survey while the most important controlling actions were identified by arranging the magnitude of RII values in their descending order. Table 4 shows the RII values, ranking positions of controlling actions and the coding system to be adopted in the proposed framework to control the operational and maintenance costs of condominiums in Sri Lanka for all sub factors under each of the main factors. RII creates values ranging from 0 to 1where 0 denotes least significance and 1 denotes highest significance

Table 4: Prioritization of Controlling Actions of Determinants

Controlling Actions	RII	Rank	Code
Building Characteristics			**A**
Building age			**A1**
Select the most suitable maintenance type and frequency	0.794	**1**	X_{1A1}
Refurbish condominium building	0.729	**2**	X_{2A1}
Upgrade services	0.503	**3**	X_{3A1}
Building area or size			**A2**
Select the most suitable maintenance type and frequency	0.748	**1**	X_{1A2}
Plan maintenance works to gain the benefit of economies of scale	0.677	**2**	X_{2A2}
Upgrade services	0.536	**3**	X_{3A2}
Building height			**A3**
Introduce maintenance free modern systems	0.626	**1**	X_{1A3}
Introduce new maintenance technologies for work at a height	0.554	**2**	X_{2A3}
Select the most suitable maintenance type and frequency	0.542	**3**	X_{3A3}
Quality level and number of building services			**A4**
Find means of increasing services' efficiency	0.742	**1**	X_{1A4}
Employ appropriate building services	0.484	**2**	X_{2A4}
Select the most suitable maintenance type and frequency	0.536	**3**	X_{3A4}
Building material			**A5**
Try to adopt maintenance free material and finishes	0.748	**1**	X_{1A5}
Use durable material and finishes	0.581	**2**	X_{2A5}
Use material and finishes which facilitate ease of maintenance	0.510	**3**	X_{3A5}
Location of the building elements			**A6**
Try to place building elements in places where it leads to less maintenance requirements	0.652	**1**	X_{1A6}
Select the most suitable maintenance type and frequency	0.613	**2**	X_{2A6}
Introduce the required maintenance tools, material, and equipment for various	0.555	**3**	X_{3A6}

elements			
Building design and construction			**A7**
Design and construct buildings that facilitate ease of maintenance and future adaptability	0.690	**1**	X_{1A7}
Ensure the participation of maintenance professionals at initial stage	0.652	**2**	X_{2A7}
Conduct proper initial requirements analysis	0.606	**3**	X_{3A7}
Building finishes			**A8**
Try to adopt maintenance free material and finishes	0.748	**1**	X_{1A8}
Use durable material and finishes	0.639	**2**	X_{2A8}
Use material and finishes which facilitate ease of maintenance	0.529	**3**	X_{3A8}
Maintenance Factors			**B**
Poor workmanship			**B1**
Train maintenance staff properly on works	0.703	**1**	X_{1B1}
Arrange effective supervision at works	0.594	**2**	X_{2B1}
Select professionals in-house, outsource maintenance staff	0.536	**3**	X_{3B1}
Poor maintenance management			**B2**
Enhance management staff knowledge on recent trends in maintenance management	0.607	**1**	X_{1B2}
Balance in-house and outsource maintenance management	0.568	**2**	X_{2B2}
Select top professional decision makers	0.407	**3**	X_{3B2}
Poor quality of spare parts and materials			**B3**
Rearrange buying policy of the condominium	0.729	**1**	X_{1B3}
Properly inspect materials before use	0.639	**2**	X_{2B3}
Maintain suppliers' non-conformity records	0.607	**3**	X_{3B3}
Budget constraints			**B4**
Ensure and enforce that all tenants pay maintenance fee on time	0.632	**1**	X_{1B4}
Maintain required level of sinking funds	0.594	**2**	X_{2B4}
Increase awareness on the importance of the appropriate furnishing of money for maintenance works	0.568	**3**	X_{3B4}
Failure to execute the maintenance at the right time			**B5**
Fix the optimum maintenance schedule, supervision and action plan	0.677	**1**	X_{1B5}
Manage an effective supply chain	0.523	**2**	X_{2B5}
Motivate maintenance staff about the application of best practice	0.432	**3**	X_{3B5}
Poor budgetary control			**B6**
Ensure proper flow of information regarding budgetary requirements	0.703	**1**	X_{1B6}
Allocate balanced budgets in every maintenance task	0.677	**2**	X_{2B6}
Practice appropriate budgeting techniques	0.510	**3**	X_{3B6}
Selection of sub-optimal maintenance strategy			**B7**
Timely analysis and modifications on maintenance strategy	0.736	**1**	X_{1B7}
Increase maintenance staff experiences on decision making	0.703	**2**	X_{2B7}
Develop continuous process for maintenance	0.542	**3**	X_{3B7}
Poor failure reporting procedure			**B8**
Timely analysis and modifications in failure reporting procedure	0.697	**1**	X_{1B8}
Preparing a well-organized failure reporting procedure	0.594	**2**	X_{2B8}
Increasing awareness on failure reporting procedure	0.542	**3**	X_{3B8}
Tenant Factors			**C**
Vandalism by tenants			**C1**
Increasing awareness on condominium living style	0.703	**1**	X_{1C1}
Increasing security system productivity	0.542	**2**	X_{2C1}
Including the vandalism cost into the fee as a penalty	0.484	**3**	X_{3C1}
Delay and failure in reporting problems			**C2**
Increase awareness on the impact of maintenance cost to the monthly fee	0.781	**1**	X_{1C2}
Active participation of tenants in condominium management work	0.658	**2**	X_{2C2}
Educating tenants about reporting problems	0.594	**3**	$X3_{C2}$

Expectations of tenants			**C3**
Include maintenance standards in tenancy agreement	0.703	**1**	X_{1C3}
Tenant participation in condominium management works	0.690	**2**	X_{2C3}
Educate tenants on the impact of quality level for their monthly fee	0.568	**3**	X_{3C3}
Accessibility to property			**C4**
Include maintenance standards in tenancy agreement	0.794	**1**	X_{1C4}
Increase awareness on the importance of building maintenance	0.639	**2**	X_{2C4}
Negotiate with tenants	0.503	**3**	X_{3C4}
Use of the property			**C5**
Introduce property operating manuals	0.690	**1**	X_{1C5}
Educate tenants	0.497	**2**	X_{2C5}
Provide financial incentives for proper use	0.400	**3**	X_{3C5}
Regulatory and Economic Factors			**D**
Changes of taxes and utility tariffs			**D1**
Prepare provisions for taxes and utility tariff changes	0.736	**1**	X_{1D1}
Keep maintenance work flexible to accommodate the change	0.568	**2**	X_{2D1}
Plan maintenance with an analysis of taxes and utility tariff changes	0.465	**3**	X_{3D1}
Changes in legislations			**D2**
Keep maintenance work flexible to accommodate legislation changes	0.677	**1**	X_{1D2}
Prepare provisions for legislations changes	0.587	**2**	X_{2D2}
Keep in touch with required legal bodies	0.516	**3**	X_{3D2}
Price inflation			**D3**
Prepare provisions for price changes	0.723	**1**	X_{1D3}
Maintain proper contract documentation regarding prices of supplies	0.684	**2**	X_{2D3}
Keep maintenance work flexible to accommodate changes	0.510	**3**	X_{3D3}
Changes in operational and maintenance standards			**D4**
Keep maintenance work flexible to accommodate changes	0.723	**1**	X_{1D4}
Undertake proper analysis prior to launching standard changes	0.581	**2**	X_{2D4}
Prepare provisions for standard changes	0.458	**3**	X_{3D4}
Other Factors			**E**
Lack of competencies of workers			**E1**
Have proper man-power enrolment policy	0.677	**1**	X_{1E1}
Arrange required training programs	0.497	**2**	X_{2E1}
Arrange frequent competency testing programs	0.400	**3**	X_{3E1}
Management decision system			**E2**
Enhance the flow of information for decision-making	0.677	**1**	X_{1E2}
Ensure participation of all concerned parties in decision-making	0.542	**2**	X_{2E2}
Require mutual understanding of professional decision makers	0.516	**3**	X_{3E2}
Building energy management system			**E3**
Motivate the best energy management practices	0.761	**1**	X_{1E3}
Integrate required energy management strategies	0.632	**2**	X_{2E3}
Improve awareness and knowledge of energy management among both tenants and the staff	0.548	**3**	X_{3E3}
Interdepartmental boundaries			**E4**
Enroll multi-skilled professionals	0.645	**1**	X_{1E4}
Enhance cooperation among interdepartmental works	0.497	**2**	X_{2E4}
Separate departmental works as much as possible	0.387	**3**	X_{3E4}
Third party vandalism			**E5**
Increase security system productivity	0.677	**1**	X_{1E5}
Extend awareness of all external parties about condominium operations	0.555	**2**	X_{2E5}
Proper legal actions for vandalism	0.445	**3**	X_{3E5}
Warranty and after-sales services of material			**E6**
Maintain proper documentation of warranty and after-sales services	0.645	**1**	X_{1E6}
Pay attention to warranty and after-sales services in the tender evaluation	0.548	**2**	X_{2E6}
Analyze market support for material and equipment	0.516	**3**	X_{3E6}

Changes in climate conditions			E7
Plan maintenance with a climate changes trend analysis	0.587	1	X_{1E7}
Keep maintenance works flexible to accommodate weather changes	0.542	2	X_{2E7}
Select the most suitable maintenance type and frequency to accommodate weather changes	0.465	3	X_{3E7}

According to the above table majority of the factors except for thirteen control actions, all the others reported a RII of greater than 0.5 marks. For most of the sub factors there were controlling actions available which has gained a RII value more than .70 marks. This clearly shows that, there are reliable controlling actions which can be put into place to regulate that O&M costs. However when main criteria are considered, "other factors" has the lowest RII scores. This reports that these factors are rather difficult to control compared with the other defined main factors. Factors like lack of competencies of workers, management decision systems, interdepartmental boundaries, third party boundaries, warranty and after sales services and changes in climatic conditions gained lower RII values for the respective controlling actions. In these O&M factors, there was no any controlling action which derived significance greater than 0.7 marks. Further, all these factors are categorised as other factors.

However, when considering the above table, it is notable that all the factors affecting O&M cost had certain controlling actions which can be put into practice. Therefore, all these above given factors are considered in the framework to control the O&M costs.

Framework to Control the Operational and Maintenance Costs of Condominiums

The ultimate objective of this study was to develop a framework providing a firm basis to control the operational and maintenance costs of condominiums built in Sri Lanka using the individual and overall significance of determinants and the corresponding prioritized actions under each determinant. The framework so developed is indicated in Figure 2 which is in the form of a modified fish bone diagram. The legend to the framework is also given in Figure 2 with the coding system to the framework given in Table 3.

In Figure 2, the arrows which are pointed towards the rectangle named 'operational and maintenance costs of condominiums' from rectangles such as A, A1, and B8 indicate how operational and maintenance costs of the local condominiums are increased due to the effects of determinants. The arrows which are pointed towards the triangles from smaller rectangles such as A1, D3, and C3 demonstrate the means of controlling the effects of determinants on the operational and maintenance costs of these condominiums. However, the triangular nodes which are directed away from smaller rectangles show the more important controlling measures whereas the triangular nodes which are directed towards smaller rectangles show the lesser important measures that can control the operational and maintenance costs of local condominiums.

By referring to this Model, it is possible to identify not only the most important main factors but also the sub-factors of those main factors that are important, both individually and as a whole along with three controlling actions that too are ranked in the Sri Lankan context in respect of each sub-factor. All the determinants and corresponding controlling actions are vital in order to control or reduce the operational and maintenance costs of condominiums. However, since it is not practical to consider the controlling actions of all determinants all at once, it would be better to address the smaller highlighted rectangles such as A1, C1, and C2 initially by adopting the highlighted controlling actions. These two highlighted categories provide the most significant determinants of O&M costs and the respective controlling actions as illustrated in Table 2 and 3 respectively.

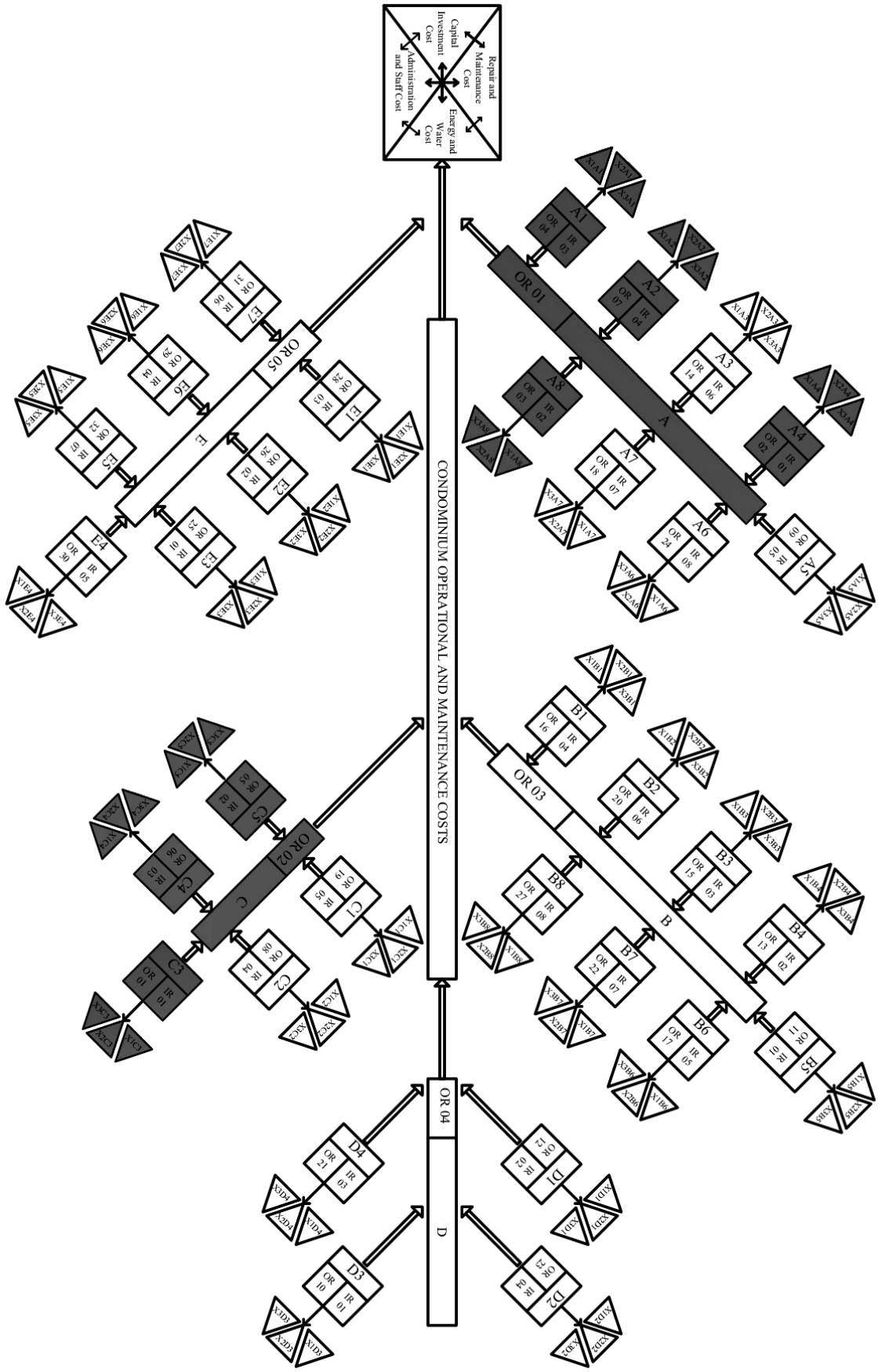

Figure 2: Framework to Control Operational and Maintenance Costs of Sri Lankan Condominiums

Conclusions and Recommendations

This study offers a framework to control the operational and maintenance costs of condominiums built in Sri Lanka prepared by tabulating their determinants in the order of their priority together with their controlling actions. (see Tables 3 and 4). The proposed framework (Figure 2) indicates the most rational way of reducing or controlling operational and maintenance costs of condominiums. This study identifies 32 dominant determining factors under five main categories. Further 92 controlling actions have also been identified. Therefore it is recommended to follow the framework and initially identify the relevant controlling action to the relevant sub factor. Then based on the most significant controlling action can be put into action in order to regulate the O&M cost. Further, according to the framework there are several controlling actions are illustrates. Further, it is organized in a way to identify the most to the least significant. Therefore, when implementing the framework it is ideal to implement the most significant in the first instance. However still it will not be practical to put in to practice all the controlling mechanisms. The highlighted options of the framework should be given priority as the corresponding determinants and their controlling actions will have the most significant impact on the O&M costs.

With reference to the data analysis, 'building characteristics' have the most significant determinants for the O&M costs. Most of these building characteristics can be selected at the design stage of the project itself so that their impact on O&M costs could be minimized. It can also be concluded that O&M costs have to be given proper consideration at the initial stages of the project itself. Finally, it is necessary to conclude that O&M costs are based on many factors. Most of these factors are controllable to a greater extent except to a very few.

Limitations and further research

This framework is not been tested in the actual scenario and purely based on the findings of the study. Therefore, lack of practical implementation would be the most significant limitation of the study. Therefore, researchers recommend adopting this framework to an actual condominium in Sri Lanka and further developing it in the actual real life context with modifications

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