MITIGATING MAINTENANCE COMPLICATIONS OF PHYSICAL SYSTEMS OF COMMERCIAL BUILDINGS IN SRI LANKA

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ABSTRACT

Maintenance is a vital part of a building to keep the property in good condition for its lifetime. A minimum number of complications increases the effectiveness of building operation and maintenance; otherwise, a knowledgeable maintenance team should implement appropriate maintenance procedures, and follow the standards to keep the building in a proper condition. During the operation stage of a building, various maintenance complications are involved in building services, such as water, electricity, and air conditioning, which are costly maintenance items. Therefore, it is necessary to mitigate the complications of such physical systems of commercial buildings to ensure its smooth operation.

The present research study aimed to mitigate maintenance complications of physical systems of commercial buildings. A qualitative research approach was adopted following a case study strategy to realize the research aim. Semi-structured interviews were conducted with the staff in the maintenance division of selected five commercial buildings as the primary data collection technique. The collected qualitative data were analyzed using manual content analysis.

The investigation identified leading eleven complications, the main causes, and sub factors affecting each complexity associated with the physical systems and other maintenance work. Complaints of tenants about the system breakdowns and quality of the construction were identified as the most common complications of physical systems. Design errors and the administration matters during the operation of the buildings are recognized as leading causes. The study further revealed that well-designed buildings have a minimum number of complications during the maintenance and operation stages.

Finally, this research provided strategies to alleviate the identified complications of commercial buildings during the maintenance period.

Keywords: Buildings, Complications, Maintenance, Strategies

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O&M - Operations and Maintenance

CEB – Ceylon Electricity Board

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Developed countries such as the United States (US) and the United Kingdom (UK) developed building management over 20 years ago. Currently, it was adapted to Asian region countries especially Singapore, Japan and Hong Kong. Both private and public sector organizations are practicing different management disciplines on building activities to gain its maximum performance (Mohd, Nurul, & Herman, 2014). Accordingly, all facilities in a building must be maintained according to its maintenance schedule to ensure they are always in good condition (Wahab, 2015). According to Ahamad (2015), building maintenance in modern era directed with return on investment and value of the facility or building. The author further stated that, building owners were expected high rate of return on their highest amount of capital or investment.

As stated by Aymen (2015), the composite amount of maintenance cost throughout the building life cycle can manage with the cost for new building construction. Hence, maintenance can be considered as significant aspects that need to highly consider and focus at the beginning of the building lifecycle. It does appear intention to maintenance aspects should be occurred from prior to the planning stage of building also. According to Anthony (2010), decisions that are taken before the operation stage of the building such as planning, design and construction stages will be impacted on maintenance cost and maintenance works of throughout the building. Horner (1997) mentioned that intention to integrate maintenance activities of building with management procedures was developed based on proper maintenance. According to that, maintenance management will be supported for maintenance manager and engineers to achieve cost effectiveness on maintenance activities of the building by ensuring health and safety and occupant's satisfaction.

According to Williamson, Williams, and Gameson (2010), maintenance professionals agree the need to allocate substantial budgets for their older building assets. Still, they do not expect to allocate large sum of money to their much younger or new buildings that are occurring issues on maintenance works at early stage of their life cycle.

Many buildings are daily erected worldwide (Chanter & Swallow, 2007). Therefore, maintenance plays an important role in continuing the building's performance (Rawlinson & Brett, 2009). According to Kiong (2012), building maintenance can be defined as a combination of both technical and administration actions that are taken to perform functions of building items and elements as acceptable standards.

Idrus (2011) stated that, maintenance roles are nominated in various ways. The author signifies that the aim is the same in maintenance management functioning in various departments namely maintenance department, facilities department, asset or building management division, property management department, logistics and administration division.

When considering operation and maintenance management, maintenance management is a critical component of the overall program of the building (Seeley, 1987). According to the opinion of Mohomad, Akasah, and Rahman (2014), operational and maintenance can be considered as a process of sustaining the documented project design intent and building owner's operational requirements. These authors mention that set of activities that support to manage building profitability and maintain building reliability were consisted with this process. As per Mohomad, Akasah, and Rahman (2014), operation defines as an events includes strategies that use to control the comfort, scheduling of equipment and ensuring energy efficient.

Building maintenance works supposed to caring the element or equipment in the facility to enhance the reliability of functions without permanent failures (Saranga & Knezevic, 2000). The author further highlighted that building elements deteriorate due to different reasons namely building materials, construction methods, operational conditions and environmental conditions of the building. Furthermore, degree of

building deterioration also depends on effects of above reasons. According to Krishnasamy, Khan, and Haddara (2005), building maintenance can be grouped into different categories such as preventive maintenance, reactive maintenance and predictive maintenance. *Preventive maintenance* involves to maintain building equipment and element systematically in order to ensure long time and most effective operational functions from particular equipment and entire system. *Reactive maintenance activities* carry out as post repairs of equipment when occur the failure and it is considered as unscheduled maintenance works. *Predictive maintenance* mainly apply to the industrial sector and this type of maintenance activities carry out based on the result of process of performing evaluating activities of equipment or system such as vibration analysis that determine and diagnose issues which cause break downs (Krishnasamy, Khan, & Haddara, 2005).

Hassanain, Froese, and Vanier (2001) highlighted that design errors are the main reason that affects maintenance complications. The design stage with the maintenance is highly desirable, contemplating on design errors, but it is very hard feasible to construct building without maintenance, furthermore adequate amount of building maintenance works at the operational stage can be minimized through design works of building at design stage (Hassanain, Froese, &Vanier, 2001). Waziri (2016) highlighted that defects at the design stage and construction stage may affect to high maintenance works at the building operation stage and it may leads to arise highest cost and dissatisfaction of the building occupants.

Despite the developed technology, some commercial buildings yet suffer from several defects due to faulty construction and design, created by unplanned maintenance during the life cycle (Orbasli & Whitbourn, 2002). The same authors mentioned that professionals might not be considered the greater part of those defects, and they ignore maintenance works during both design stage and construction stage. This leads to occur continuous repairs and maintenance works, that often to arise high cost and cause to dissatisfaction of building occupants.

Seely (1987) reported that most of designers are commonly unaware of the effects of their design alternations until the post-occupancy survey period. The author also

mentions that it is imperative to consider maintenance at both design and construction stages by incorporating maintenance variables to trim the subsequent maintenance effort during occupancy. Moreover, Adenuga and Dosumu (2012) stated that project design team (designers, architectures, engineers, facilities manager and contractors and all major parties in construction project) has responsibility to ensure effective building design while concerning building maintainability and everyone must involve to it without leaving, because of they ignore that emergency maintenance will be occurred at construction and operational stage of building. The engagement of the facilities manager at the design stage of building has been taken significant impact to minimize maintenance work during building occupancy stage (Walter & Flapper, 2017).

The inability of the design professionals to produce well-coordinated, complete and accurate design generated faults, which may come together based on omission or design defect or combination of both (Gatlin, 2013). More recently, Kiong and Akasah (2011) viewed that building life span depends on mainly maintainability and design criteria in building. In pursue of Seeley (1987), effectiveness of the building has been decided based on three criteria such as aesthetic values of particular building and performance of building elements as accepted standards and degree of accessibility to conduct maintenance activities.

1.2 Research Problem

As discussed in the background study, all facilities in a building must be maintained according to its maintenance schedule to enhance that they are always in good condition (Wahab, 2015). Further, maintenance leads to create a comfort build environment for the occupants in the building. It is noted that the patterns, methodologies, techniques, and objectives of the building have changed periodically. Therefore, the present building construction has a broad subject area to fulfil modern society needs. Accordingly, the designed philosophies of a building are still improving. Regarding the commercial building complex, clients of the commercial building seek maximization of their earnings, and aspiration of the occupants is a high comfort environment and continuity of services in the premises.

In this context, the involvement of professionals in operation and maintenance is vital to maintain the buildings. According to Walter and Flapper (2017), the contribution of maintenance responsible persons such as maintenance engineers, Facilities manager, or Maintenance manager at the design stage has the potential to reduce maintainability during the facility operation. Therefore, the maintenance team must be a middleman for the satisfaction of both the client and the occupant in the building. As stated in the background, staffs in the maintenance division must face many maintenance issues during the operations of buildings. Thus, the absence of proper actions towards such complications ultimately results in massive damage to the construction.

1.3 Aim and Objectives

1.3.1 Aim

The research aims to mitigate the maintenance complications of physical systems of commercial buildings in Sri Lanka.

1.3.2 Objectives

The following objectives were setup to achieve the aim:

1. Identify the common maintenance complications of physical systems of commercial buildings
2. Examine the causes and factors that affect maintenance complications during the operation
3. Provide strategies to mitigate the maintenance complications of commercial buildings.

1.4 Research Methodology

Literature surveys helped to find previous research on the subject, and maintenance issues in commercial buildings. The literature review also identified the definitions of maintenance, evaluation of maintenance, types of maintenance, and the effects of

maintenance. A qualitative approach was used, and five (5) cases were selected for adopting a case study strategy.

Semi-structured interviews were held during data collection to continue with the research objectives. Divisional heads and members of the maintenance staff participated in the interviews. Data were analyzed using grounded theory.

1.5 Scope and Limitations

This research study focuses on the complications related to the maintenance of physical systems of commercial buildings in Sri Lanka. The physical systems include HVAC, electrical, fire protection, plumbing, and drainage systems. The study was limited to structures belong to the commercial sector in the Colombo area.

1.6 Chapter Breakdown

Chapter One- Introduction to the research

This chapter discussed the research background, problem statement, aim, objectives, methodology, scope, and limitations of the investigation.

Chapter Two- Literature Review

Chapter Two discusses the previous studies by gathering the existing information regarding the research problem and provides a clear image of the research problem.

Chapter Three- Research Methodology

Chapter Three discusses the research method, research settings and research design, and the method of data analysis.

Chapter Four- Data Collection and Analysis

Five Cases were selected, and data were collected from the semi-structured interview survey. The chapter discusses the survey results and presents the research findings.

Chapter Five - Conclusions and Recommendations

The chapter presents conclusions and recommendations based on research findings, limitations of the research, and further research.

1.7 Chapter Summary

Chapter One describes the background to the research, research problem, aim, and objectives. It also explains the research methodology, the scope and limitations, and the chapter breakdown.

CHAPTER TWO

2.0 LITERATURE SYNTHESIS

2.1 Introduction

Chapter one provided an introduction to this study. Second chapter of this study utilize to carry out comprehensive literature review on the research area includes maintenance and operation and O&M issues in the commercial buildings. As well as the chapter provides definitions of maintenance, concept of building maintenance, types of maintenance, maintenance cost and factors affecting the implementation of practical maintenance.

2.2 Building Maintenance

Building maintenance concept is highly applicable but it was harder to create building without maintenance work because every buildings are deteriorate due to different reasons such as building materials, construction methods, operational conditions and environmental conditions (Adenuga & Sotunbo, 2014; Rooley, 1993). The authors further mentioned that activities at design stage are highly directed to maintainability at the operation stage of building and effectiveness of those activities affect to reduce maintenance cost and time throughout the building life cycle. According to Sapp (2017), building operation and maintenance relates to wide range of tools, services, competencies and processes that need to ensure the built environment in order to perform functions of facility as desired. Concept of operation and maintenance consist with regular operations that are required for the building structure, its equipment and systems and building users to perform their desired functions. The term of O&M became as a result of combination of the operation and maintenance concepts because of a building cannot be operated with maximum efficiency without maintenance. Therefore, those concepts should be discussed as one concept.

The effectiveness of functions of the building or facility depends on appropriate operations and maintenance (O&M) of building (Joseph, Lai &Francis, 2007). The

authors further stated that commercial building in modern era basically consisted with different services installations such as electrical, plumbing, air conditioning, fire detection and protection system and drainage installations.

Currently, building maintenance is gaining high determination in most of developing countries throughout the world due to the development of demand on housing and its impact on the current status of the facilities may consider as a one option of sustaining current stock of infrastructural amenities (Alan, Forster & Brit, 2009). Maintenance needs different actions to gain its success such as proper technical knowledge on material usage, accurate method for diagnosis of defects, well defined remedial actions and knowledge on resource management as well as initiation and follow up the integrated plans and policies to sustain the value (Mossel & Jansen, 2010). Zawawi et al (2011) emphasized that, main aim of maintenance is to preserve functions of the facility throughout the building life span same as its initiate stage. The author further stated that, maintenance also carry out to gain maximum value on investment while maintaining good appearance and conditions of building continuously. Further same authors described that maintenance can, therefore, denote to all the required work done to preserve a facility with its finishes and accessories, so that it continues to provide the same or almost the facilities and function as it did when it was built.

2.3 Evolution in Maintenance Thinking

Forster and Kayan, (2009) have described their distinct generations of maintenance as 1st Generation, 2nd Generation and 3rd Generation. Until to time of 2nd World War, industries in world were not mechanized and down time is not taken significant place within the industries. Systems and equipment were not much complex and most of system and equipment were over designed. As a result of that, reliability and availability of systems are well maintained and maintenance process is not an essential in industry. 2nd generation describe during 2nd World Wartime pressures developed the demand for all types of commodities, while the supply of skilled labors dropped sharply. This led to improved mechanization and by the 1950s industry based on reliable machinery. In that era, concept of the preventive

maintenance was developed due to requirement of prevent the equipment from failures.

Maintenance cost of the building initiates to incur dramatically in relative to other cost of operations, planning of maintenance works and control of the systems. An assessment of the maintenance process and maintenance policies in most of facilities specify that the first generation is, even now, the standard form of maintenance.

Slack (2001) stated that continuous improvement is often arguing for a high level of preventive maintenance to reduce the risk for unplanned interruptions and breakdowns in the production. In the 3rd Generation the persons who engaged in set up the maintenance responsibilities and duties have been differed. Accordingly, role of the facilities manager has been became as recognition profession. Unwanted out sourcing of maintenance works, usually under a combination of 1st and 2nd generation maintenance works, with a grueling performance clause does not focus on the operation of the systems in context and the significant objective of sustaining a better built environment, manage the levels of operating budget, product quality and safety needs (Khazraei & Deuse, 2011).

Concept of the maintainability is an essential function in today's market due to high competition and it may leads to accomplish strategic objectives of particular organization (Fraser, 2014). Through the maintenance, maximum productivity from the facility can be achieved. It consists with two main actions as planned and unplanned conducted to keep a physical property within acceptable operational conditions (Faccio, Persona, Sgarbossa, &Zanin, 2014). According to that, maintenance of building focus to improving the value of the reliability, improve the quality of property, availability and fulfill the safety needs (e.g. production plant, equipment, or building) with desirable economical costs (Márquez, 2007).

2.4 Definition for Maintenance

The purpose of maintenance management can be revealed as make sure the performance of equipment or system as desired and restored the systems to good conditions if they have been faced to failure or breakdown (Hassanain, Froese, and

Vanier, 2001). The authors further stated that, maintenance consists with four main actions namely technical actions, administrative actions, management actions and supervising actions.

The significance of maintenance was elaborated by all legislations and documentations, but definitions of maintenance have not been yet denoted it well (Mohamad, Akasah, &Rahman, 2014).

According to Seeley (1993), BS 8311, maintenance referred as *"the combination of all technical and associated administrative actions to retain an item in, or restore it to, a state in which it can perform its required function"*.

A broader definition of maintenance has been adopted by Feilden and Jokilehto (1993) as *"all practical and technical measures to keep the building or site at a standard that permits enjoyment of their cultural senescence and resources without damage"*.

Moreover, Odediran and Opatunji (2012) also utilize broader interpretation for the maintenance as *"a continuous protective care of the fabric, contents and setting of a place"*. It is clear that various definitions have been utilized to describe maintenance.

According to the definition of maintenance BS 38113, maintenance defined as, *"The combination of all technical and associated administrative actions intended to retain an item in, or restore it to, a state in which it can perform its required function"*.

2.4 The Three Stages of Maintenance

Maintenance cannot be considered as a function that only applicable for the operation stage of the building. Because of maintenance of building should be planned from initial stage of the construction project. It was clarified through European building sector. Because of that maintenance and repair activities in European building sector can account for up to 40-60% of the building construction cost. It does appear requirement to improve the durability of building systems during its design and construction stages (European Commission, 2012).

According to Bjarnason (2013), the process of maintenance consists with three (03) main stages as follow:

- Planning and design stage:

Maintenance process of the building start at this stage. During this stage, client needs to construct or build a facility according to his requirements. Basically client discuss with a designer to finalize the design of the facility. During this process, designer must be concerned on maintenance aspects of particular facility. It can be complied by obtaining advises from facilities manager or maintenance manager/engineer. Furthermore, different methods and tools namely life cycle cost assessment and BIM, so on can be utilized to identify the significance of maintenance aspects in a facility. Based on all accurate information, designer should be finalized the design of the facility while concerning maintainability.

- Construction stage:

To meet with the lowest maintenance cost throughout the building life cycle, proper construction methods must be applied at construction stage while ensuring all acceptable quality requirements of construction works. For that purpose, certain quality assessment and management tools were utilized at this stage.

- Maintenance stage:

This stage is became as result of use of the building. After the completion of building, it is handover to client for usage of it's as desired. However, buildings are deteriorating due to its usage. In such cases, maintenance actions to be taken to maintain effective functions of the building. For that purpose, suitable maintenance activities should be carried out as planned or unplanned actions. All necessary information on systems and installations should be handover to building owner at handover stage by the contract for proper maintenance (Byggeskadefonden, 2013).

2.5 Types of Maintenance

The design life of most equipment and system requires periodic maintenance. Various approaches that have the ability to perform maintenance within facility

introduced and they are supposing to ensure system or equipment achieve their maximum life time in an effective manner as design life. Maintenance has been grouped into two main categories as planned maintenance (Proactive) and unplanned maintenance (Reactive). Excluding the maintenance that carry out after occur breakdown (reactive maintenance), other approaches can be known as preventive maintenance, predictive maintenance, or reliability centered maintenance.

Khazraei and Deuse (2011) suggested a categorization of maintenance through their study based on the tactics related to the conventional maintenance disciples. The authors shown two main strategies in maintenance as reactive and proactive maintenance. They are linking with different tactics of maintenance as shown in Figure 2-1.

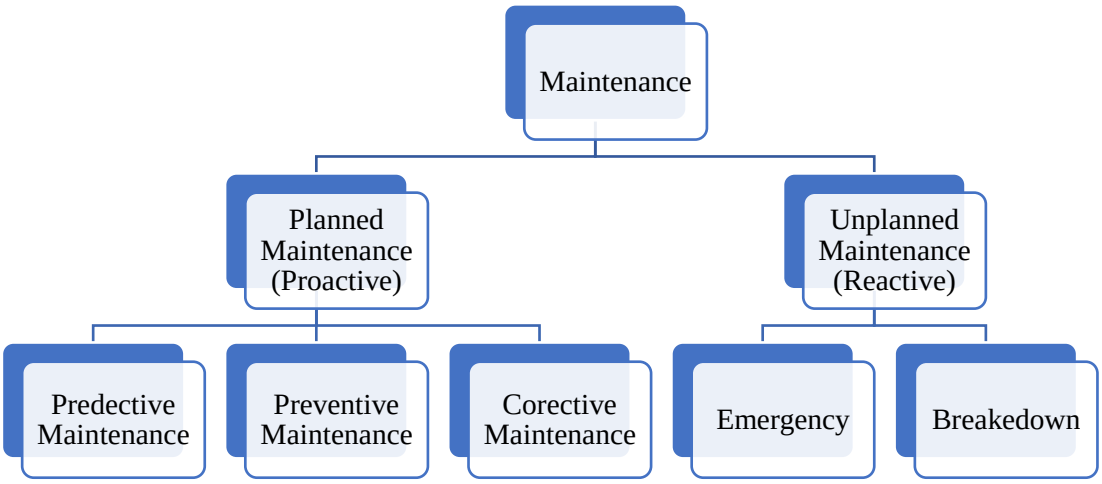


Figure 2-1Types of Maintenance

Source: Khazraei and Deuse (2011)

- **Planned maintenance**

As depicted in Figure 2-1, planned maintenance named as proactive maintenance, it has classified three categories of predictive, preventive and corrective maintenance.

- **Predictive maintenance**

Predictive maintenance referred as *"measurements that detect the onset of system degradation (lower functional state), thereby allowing causal stressors to be eliminated or controlled prior to any significant deterioration in the component physical state"* (Horner, Haram & Munns, 1997). Moreover, Horner, Haram and Munns (1997) emphasized that existing and future capabilities on functions. When doing the comparison between the predictive and preventive maintenance, predictive maintenance has been differed from preventive maintenance because it is carried out based on the actual condition of the system or equipment without following any pre-determined time period as scheduled (De Groote, 1995).

- **Preventive Maintenance**

Preventive maintenance is referred as *"actions performed on a time or machine-run-based schedule that detect, or mitigate degradation of a component or system with the aim of sustaining or extending its useful life through controlling degradation to an acceptable level"* (Lai, 2010). According to Lima and Castilho (2006), preventive maintenance is performed to prevent from system failures, safety issues and unexpected production losses whereas preventive maintenance carry out before the failure has occurred. Preventive maintenance has not been unique way and past researchers were found out different best ways to perform preventive maintenance activities. Preventive maintenance can be considered as an effective in preventing age regards to breakdown of system based on recent research findings. For unplanned breakdown patterns that amount to 80% of the breakdown patterns, condition monitoring confirmed to be effective.

- **Corrective Maintenance**

Corrective maintenance is known as maintenance that is needed when a system or equipment has been occurred failure or breakdown, to keep it back to good working condition. Corrective maintenance can be considered as activities that are conducted

on all systems and equipment where the consequences of breakdown are not important and maintenance cost is higher than preventive maintenance. According to Pinto and Xavier (2007), it refer as corrective actions of less performance than desired or breakdown, for decisions at managerial level, i.e., for less performance from predictive maintenance or take an action until breakdown has been occurred.

- **Reactive maintenance**

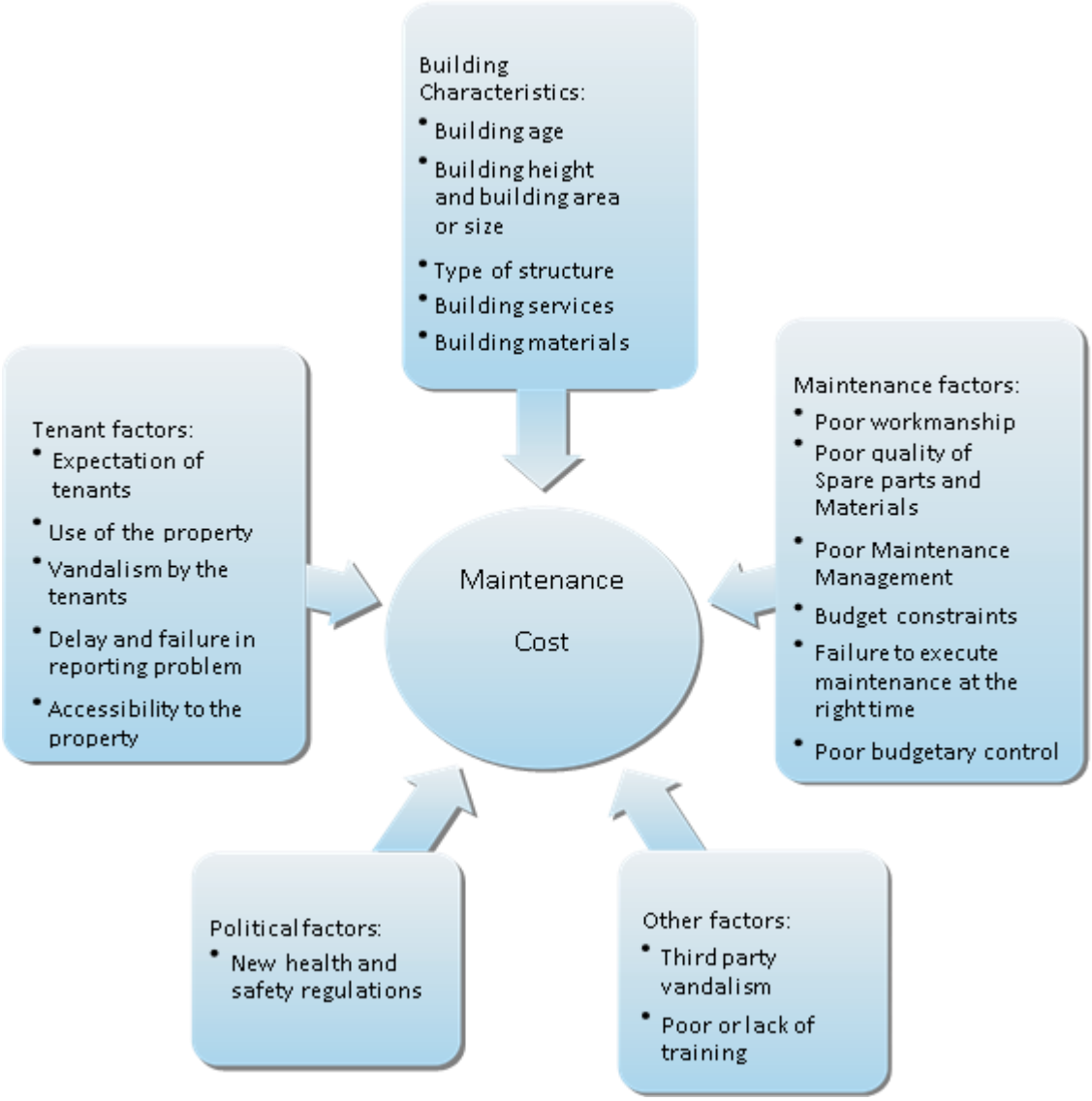
Reactive maintenance is mainly the "run it till it breaks" maintenance method (Aye, 1943). The author further stated that there no any actions are applied to maintain the system as designed originally intended to enhance design life is accomplished.

2.6 Maintenance Cost

Complicated operation and maintenance issues effect to increase the maintenance cost of the buildings (Ali et al., 2010). According to Horner, El-Haram and Munns (1997), reduction of the requirement of repair on defects in the building while accomplishing planning and implementation, acquiring appropriate materials, methods and tools at the right time can be considered as a main objective of maintenance management.

Reliability of systems by enhancing safety and energy efficiency can be achieved through effective O&M process in building (Akasah, Abdul and Zuraidi, 2011). Moreover, the authors further stated that wastage of energy in both public and private sector is happened as a result of insufficient maintenance of energy-using systems such as water and air leaks, energy losses from steam, insulated lines, maladjusted or inoperable controls, water and air leaks and other losses due to poor maintenance are often taken into account (Akbar, 2006). As well as proper maintenance processes can create significant saving relates to the energy consumption and it can be concerned as one of resource. Furthermore, development of the building maintenance program can often be fulfilled directly with a low cost of approximately (Rooley, 1993). Maintenance aspects are favor to have high impact on costs on maintenance works of houses (El-Haram, Horner & Munns, 1997). The authors further stated that, commonly, maintenance factors are grouped into two main factors as technical

factors and administration factors. Technical factors are compromised with some of factors that influence on maintenance cost such as poor quality of building materials and tools and poor workmanship. According to Kamaruzzaman, Sulaiman, and Peng, (2010) has identified some factors which affected for the maintenance cost as building characteristics, maintenance factors, Tenants factors political factors and other factors and present in Figure 2-2.



Source: Kamaruzzaman, Sulaiman, andPeng, (2010)

Figure 2-2 Maintenance Cost

2.7 Definition of Complication

There are different definitions for the complications. Accordingly merriam-webster (2020) complication can be defined as follows.

- A making difficult, involved, or intricate
- A complex or intricate feature or element

- A difficult factor or issue often appearing unexpectedly and changing existing plans, methods, or attitudes

As such in this research used the word maintenance complication for the issues of the maintenance often appearing during the maintenance processes.

2.8 Complications of Maintenance

Maintenance of the systems can be done as preventive, predictive and corrective as discussed in Section 2 In most of the cases inadequate preventive maintenance has increased emergency breakdowns and increases the frequency of corrective maintenance. It may influence to create the major breakdowns in the systems(Brian 2005).

Design Quality Indicator could be effectively utilized during the design stage of new building projects to prevent or reduce premature and unnecessary future building maintenance.(Williamson, Williams & Gameson, 2010)

According to Alshehri and Ogunlana (2015), the common problems faced by the maintenance department mainly due to the Top Management Problems, Poor Management of Maintenance Team, Procurement Management, Unqualified Maintenance Contractor, Government Regulations and Rules, Stakeholders Communications, Financial Issues, Lack of Supervision from Maintenance Team, Lack of Engineers and Specialist, Unclear Job Description and Department Structure, Lack of Maintenance Software Tool, Failure of Preventive Maintenance.

On the other hand, equipment in the building that is not maintained or operated properly may affect to the performance of the whole building. As well as poorly placed equipment is coming under design issue and makes it difficult to access equipment to perform maintenance tasks as well. This may indicate that maintenance does not get done as often as it should.

Building services are costly maintenance items and their lives are usually much less than those of the buildings, which accommodate them (Ruegg, 1984). Hence particular care should be taken in the selection, design and installation of these

services to ensure that maintenance can be carried out easily, quickly and economically (Saranga & Knezevic, 2001) and also same authors highlighted that the all services should be readily accessible with adequate access and working space provided. The system issues created by inadequate spaces provided for the systems and unplanned installations. As per the study done by Olanrewaju and Abdul-Aziz, (2014) operation and maintenance issues can be listed under category of Electrical system, civil works, HVAC system, space planning, transportation and plumbing system. According to the Olanrewaju and Abdul-Aziz, (2014) mentioned distribution issues, capacity issues, inadequate provision for modification as the Issues in the electrical systems.

HVAC maintenance problems varies due to few factors including building and types of the HVAC systems, vintage (design efficiencies), and climates. The maintenance issues with considerable energy impacts for buildings are OA damper stuck at 100% position, supply air temperature offset, blocked OA screen, chiller fouling, and chiller refrigerant under or overcharge. Although there is no significant energy impact due to cooling coil fouling, the numbers of unmet thermal comfort hours for both heating and cooling are significantly increased due to reduced system cooling and heating capacities. The overall energy penalty by combining the sampled maintenance issues including sensor offset by +2 ˚C can reach 85% of overall HVAC energy consumption according to climate (Wang & Hong, 2013).

As stated by Olanrewaju and Abdul-Aziz, (2014) complications of civil work scan be listed as inadequate provision for modification, Water leakage and due to types of materials used.

According to Funtna and Gana (2015), issues of the elevator systems have occurred due to very week due to poor maintenance, shortage of skilled manpower, and/or lack of qualitative spear parts. The occupants also confirmed that in many cases maintenance managers allow the system (lifts) to breakdown before fixing it. In other words small signs of elevator's failure are not attended to until it further deteriorate and affect its normal functions; as a result of lack of available skilled professionals to attend to it within the vicinity or the period of time it takes for the maintenance

manager to make request for the rectifications. Elevator includes various parts which have separate life cycle, some part have to replace before the others in order to maintain shape, function and Appearance. The movement of people in a high rise building takes on different characteristics depending on the building use, time of the day, and other factors (Arthur et al, 2003). The efficient dispatching of people requesting service from an elevator in a high rise building will also depend on different factors such as number of servers, queuing capacity, number of elevators, dispatch time or speed and so on. These eventually cause queuing problem at lobbies especially at up peak period. As a result, passengers wait for long time before getting the service of the elevator. Noise and Vibration is another issue due to the age and inadequacies in design and maintenance of some elevators, the lifts were found to be vibrating too much with rising interior noise making the passengers uncomfortable especially the age class that could not use the stairs in getting to the upper floors easily.

According to Kamble and Kumthekar (2015) stated the issues in the Plumbing Systems are leakages, low pressure, breakage, corrosion of pipes and Poor Installation of Pipes during Construction. These problems revolve around two things: material used for pipes, and how pipes are installed by the worker. Leaking pipes are major issues. It not only wastes the water but also affects daily routine of the occupants. Constant leakages through pipes in walls lead to water seepage, which may damage structural components of the building. Leakages may prove to be costly, if the problem is left undetected. Other problem is cracks in pipes and this occur due to poor material quality, mishandling on site, hammering of heavy tool and due to external temperature. In addition to that Olanrewaju and Abdul-Aziz, (2014) stated the other issues in the plumbing systems are inadequate provisions for the modifications, inadequate space allocation for the repair of the plumbing system, inadequate facilities for the water sump, overhead tanks like water filling, distribution and cleaning and different valves use for wrong purposes – As an example spring type non return valve has been used for the places where need door type non return valve.

According to Suffian (2013), some common issues identified in the building such as Waterproofing Issues, Warranty Issues, Cracks. Further same author mentioned that Lacks of Knowledge and Expertise on Maintenance aspects very common issue that the building maintenance is merely interpreted as an aspect of maintenance of building system such as elevators, air conditioning, lighting, etc. Therefore the maintenance groups are dominated by those with mechanical and electrical background with limited knowledge on civil and structural aspects. As a result, the repair approach for the particular area is not so good that resulting the problems to recur. Accordingly, Suffian (2013) recommended to taking appropriate measure by getting the expertise of civil engineers to regularly monitor the condition of the buildings as a preventive measure. If any defects occur, the engineer would then come up with the best solution of the repair works and closely monitors its implementation.

2.8 Chapter Summary

This chapter described the building maintenance, its evaluation, as well as the type of maintenance, maintenance cost and complications of the maintenance. This chapter developed by collecting all the relevant data which wants to give a path to conduct the research. Initially identified the evaluation of maintenance, maintenance cost and various kinds of definitions about maintenance which provided by expertise. Then identified and discuss about the types of maintenance. As mentioned in the literature, there were number of issues of maintenance in the building projects.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

Research methodology chapter was used to mitigate maintenance complications of physical systems of commercial buildings in Sri Lanka. This chapter explains the systematic approach that was applied to carry out this study by achieving research aim and objectives. The study which is carried out based logical way must be follow a research process (Tan, 2002). It build up the research based on a systematical way by accomplishing research aim and objectives.

Further, the chapter deliberates research approaches, research strategy and research method, which used to data collection and data analysis. The accomplishment of the research aim and objectives always directed with data collection techniques and data analysis techniques. Hence, selection of an appropriate techniques to collect and analyze the data is very important.

3.2 Research design

Research design denotes the process of solving the research question by carry out the research from background study to conclusion (Tan, 2002). Research designs engage to choose suitable research approach and identifying the unit of analysis and sampling technique (Punch, 2005). Thus, research design respectively consists with initial study, literature survey, research methods that is data collection, data analysis, and research findings by adapting appropriate research approach and research strategy.

3.3 Research Approach

Many researches recognized mainly three (03) research approaches as qualitative approach, quantitative approach and mixed approach. Fellows and Lui (2003) explained qualitative approach is applied to discuss the ideas and collect data from

opinions of the people or expertise, views of people, people's understandings and identify beliefs whereas qualitative approach uses to study about whole people as groups or individuals. Moreover, Fellows et al., (2003) stated that a qualitative approach gathers factual data and analyze the relationships between such factual data and theories. Quantitative data is any data that are in numerical form such as statistics, percentages, etc. The researcher analyses the data with the help of statistics and expects that the numbers will yield an unbiased result which can be generalized to some larger population. Qualitative research, on the other hand, inquires deeply into specific experiences, with the intention of describing and exploring meaning through text, narrative, or visual-based data, by developing themes exclusive to that set of participants. As delineated by many scholars, experimental and survey researches are included into quantitative approaches.

The mixed research approach is an approach develops as a combination of both qualitative research approach and quantitative research approaches. Through this approach, data will be collected from both qualitative data collection techniques and quantitative techniques.

By considering the research aim of mitigate maintenance complications of physical systems of commercial buildings in Sri Lanka, qualitative research approach was selected as most appropriate research approach in this study

3.4 Research Strategy

This section presents suitable strategy used for data collection and data analysis. Many Scholars have identified, experiments, surveys, case studies, action research, grounded theories, ethnography, and archival research are the main research strategies commonly used (Creswell, 2009; Suanders, et al. 2009; Yin, 2009). Case studies are appropriate where the objective is to study the contemporary phenomenon and where it is not necessary to control behavioural events or variables (Yin, 2009). As Morris and Wood (1991), a case study strategy is suitable in situations where there is broad understanding of the research context and process. As explained by Yin (2009), it is crucial to gain some depth understanding of the current maintenance

practices in commercial buildings. Therefore, by considering the research aim, case study strategy has selected in this study as most appropriate strategy.

3.4.1 Case Selection

Population size, its homogeneity, the sample media and its cost of use, and the degree of precision required when selecting a case (Salant & Dillman, 1994). The people selected to participate in the sample must be selected at random; they must have an equal (or known) chance of being selected (p. 13). Salant and Dillman (1994) stated the prerequisite of sample selection by targeting population as narrowly as possible (p. 58). It is not oftenpossible but need to know the true population. In such cases, Attewell and Rule (1991) suggested that the ability of using theoretical sample. Accordingly, in this research it has selected five (5) cases to represent all the commercial buildings in Sri Lanka.

3.4.2. Case boundary and unit of analysis

The case boundary of this research was commercial buildings in Sri Lanka and maintenance complications were the unit of analysis.

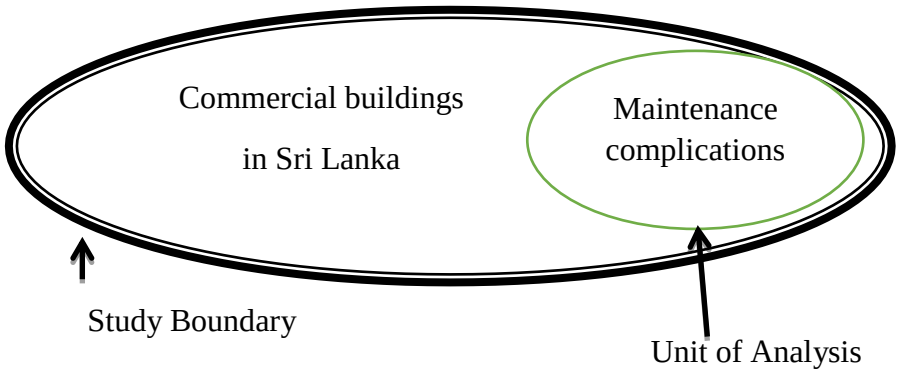


Figure 3-1Unit of Analysis and Study Boundary

3.5 Data Collection

Semi structured Interview guidelines distributed among the staff of maintenance division including divisional head, maintenance Engineers, maintenance Managers, Senior Technical Officers and Supervisors to gather the maintenances complications of physical systems, causes and the suitable strategies to mitigate those.

3.6 Data Analysis

Research study has collected qualitative data through five (05) case studies through semi-structured interviews across management level and operational level employees in the maintenance division. Manual content analysis was used to analyse qualitative data while adopting individual and cross case analysis.

3.7 Research process

According to Kothari (2004), research process refers a series of actions or steps which effectively carry out in research as per desired sequencing of steps.The research process plays a pivotal role in science. To support research project and researchers, it is essential to understand the research process and its stages. Although the literature offers different research processes, these are often focused on specific research paradigms and methods (Helena, 2006). The research process adopted in this study has illustrated in Figure 3.2.

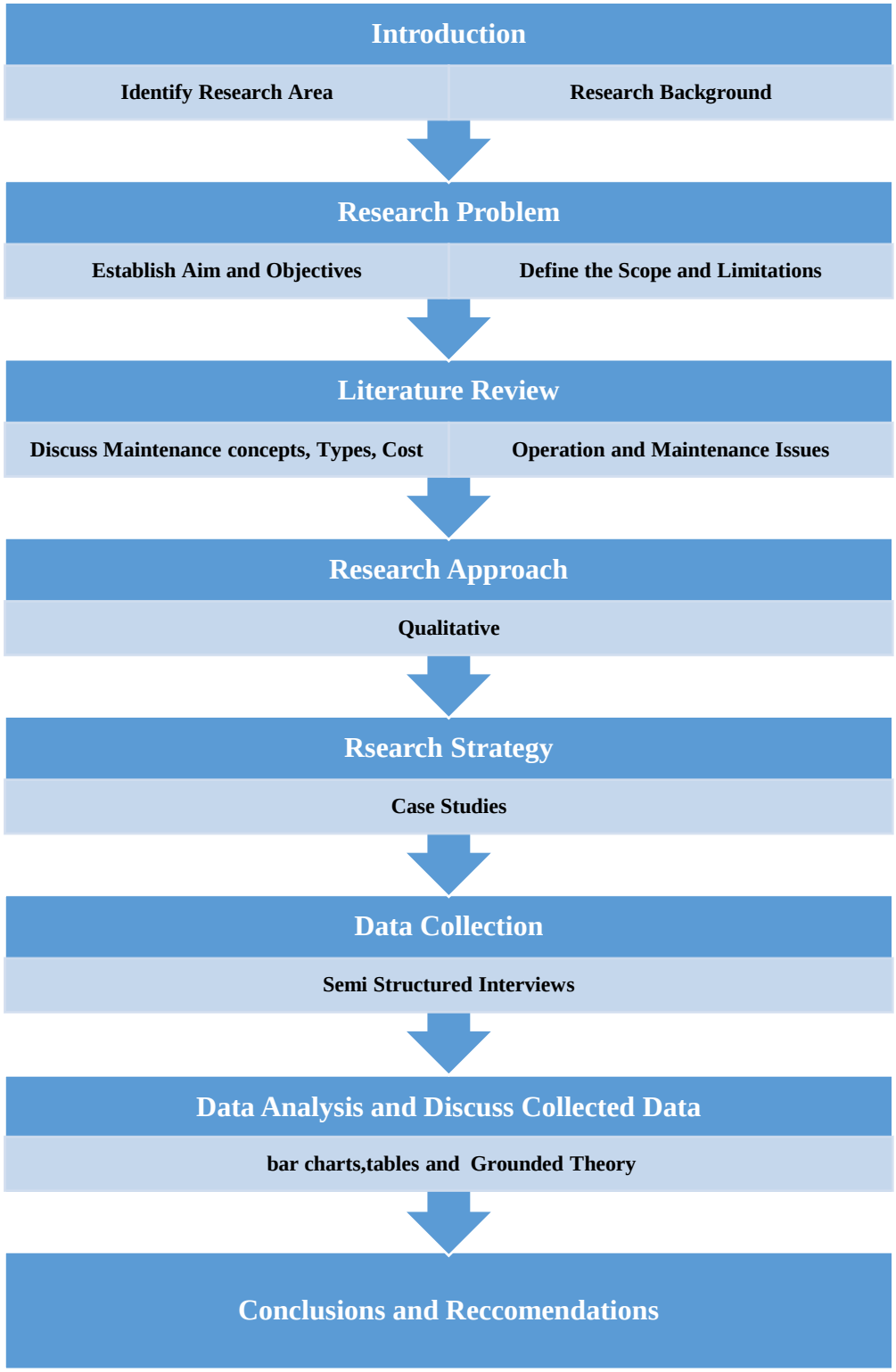


Figure 3-2 Research Process

3.8 Chapter Summary

Chapter three elaborated the methodology of the research, including research design, research process, research approaches, research strategy, data collection techniques and data analysis methods. After analyzing all the approaches, qualitative research approach has selected as a most suitable research approach. Case study strategy has selected to address the research problem. Semi structured interviews were used to gathered data and grounded theory was used as the analysis tool.

CHAPTER FOUR

4.0 DATA ANALYSIS

4.1 Introduction

In the research methodology chapter discussed the way, which uses to collect data to identify operation and maintenance complications in the Commercial Building and the way of mitigating that complications. In the data analysis chapter clarify the collected data through the semi structured interviews. Five (05) Commercial Buildings have been used for the case studies. Top management and maintenance staff in those buildings were taken part for the interviews.

Bar charts and tables have been used to analyze the collected data from the semi structured interviews as analytical tools. Content analysis technique has been used to analyze the data, gathered through the interview survey and it's done by manually. Through this chapter, the researcher has identified the maintenance complications; causes effected and provided the strategies to mitigate the maintenance complications in the physical systems of commercial buildings in Sri Lanka.

4.2 Profile of the case studies and Respondents

Case study strategy facilitated the exploration and analysis of maintenance complications of physical systems of commercial buildings. These sections presents details of Cases studies and data collections through semi – structured interviews.

4.2.1 Profile of Case Studies

There are five (05) commercial buildings have been selected for case study to identify the complications of maintenance, causes affected and strategies to mitigate the complications through the interviews. The details of the selected five (05) buildings are presented in Table 4-1.further Figure 4-1 illustrates the expected life time of the selected buildings.

Table 4-1 Details of the Cases

Case	Construction Period	Age of the Building	Expected Life Time of the Building	Types of the Occupants
Case 1 (C1)	5 Years	33 Years	100 Years	Tenants- Government
Case 2 (C2)	3 Years	3 Years	75 Years	Own staff- Private
Case 3 (C3)	5 Years	15 Years	100 Years	Own and Tenants- Private
Case 4 (C4)	3 Years	8 Years	50 Years	Own and Tenants- Private
Case 5 (C5)	3 Years	3 Years	50 Years	Tenants- Government

Buildings are erected expecting different ages for them, accordingly, Figure 4-1 demonstrates the expected life time, age of the building and construction period of the selected buildings graphically.

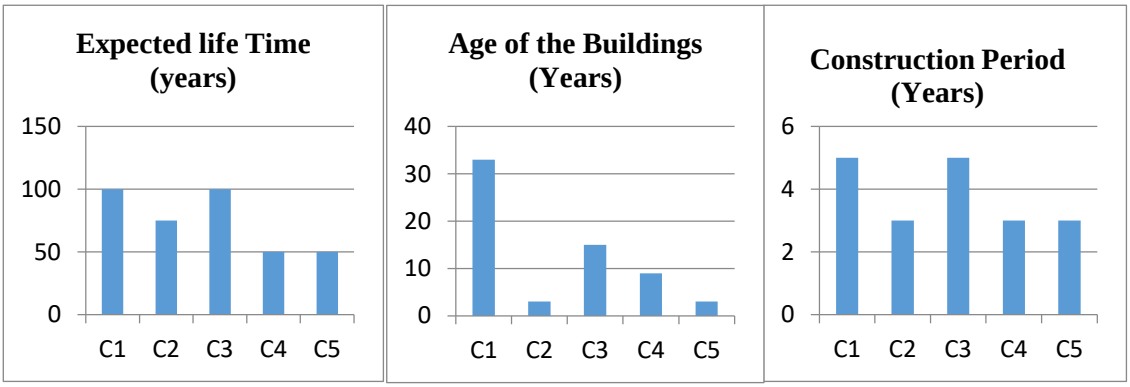


Figure 4-1 Expected Life Time, Age of the Building and construction period

According to Figure 4-1, the selected buildings have different age and C2 & C5 buildings have age less than 5 years. Expected lifetimes of the selected buildings are between the 50 to 100 years. There were three (03) types of occupants in the Selected buildings such as Government tenants, Own staff in private sector and own staff and tenants in private sector.

4.2.2. Details of the respondents

Staffs at maintenance division including top management, assistance managers-maintenance, supervisors- maintenance, Technical Officers and Senior Technicians were selected for the semi structured interviews. They comprised with different level of experience and were used to identify the maintenance complications of physical systems and provide strategies to mitigate the identified complications. Designations and experience of the respondents are presented in Table 4-2.Results obtained from interviews are presented in subsequent sections of this chapter.

Table 4-2 Profile of the Respondents

Case	**Respondent Designation**	**Respondent ID**	**Experience of the respondents**
Case 1 (C1)	Director –Engineering Services	C1R1	22 Years
	Supervisor MEPCC	C1R2	18 years
	Technical Officer	C1R3	4 years
	Technical Officer	C1R4	16 years
Case 2 (C2)	Head of Facilities Management	C2R1	5 years
	Assistant Manager Operation	C2R2	4 years
	Senior Technician	C2R3	16 years
Case 3 (C3)	Chief Operating Officer	C3R1	18 years
	Technician	C3R2	14 years
	Assistant Operating Officer	C3R3	3years
Case 4 (C4)	Manager Engineering	C4R1	8 years
	Senior Technician	C4R2	13 years
	Assistant Manager Engineering	C4R3	6 years
Case 5	Manager – Technical	C5R1	3 years

(C5)	Technician	C5R2	6 years
	Supervisor Technical	C5R3	10 years
	Team Leader MEPCC	C5R4	12 years

4.3 Current Maintenance Complications in Commercial Buildings

The first step of the data collection was to identify the current maintenance complications in commercial buildings. Therefore, respondents were asked to expose their experience and existing maintenance issues relevant to the physical systems in the selected cases. Findings of each case are presented in case wise.

4.3.1 Maintenance complications of Case 1

Case 1 was a commercial building, which occupy with government tenants. The building has rented out for the government organization including Ministries. One of top management (C1R1) and three members from the maintenance staff (C1R2, C1R3, C1R4) were interviewed during the data collection.

As explained by C1R1, different types of issues have been faced during his job task mainly due to the lack of design of maintainability. C1R1 stated that unable to get separate electricity usage readings (consumptions) to separate tenant's areas as a main complication. Therefore, it is difficult to issue electricity invoices for tenants. Further C1R1 stated that improper space planning is another complication and most of the tenants are changing their internal space arrangements/modifications, data wirings without informing to the Management of O&M. Accordingly, it has generated more and more errors in the systems like electricity distributions and Air conditioning systems.

C1R2 and C1R3 also explained the same complications as mentioned by C1R1, in addition to that C1R2 and C1R3 mentioned a complication of difficult to handle and rectify the complains which received by the tenants for system breakdown on time. In addition to that C1R2, C1R3 and C1R4 stated that conduct of maintenance work at

the tenant area as another complication which they had to face during their job tasks. C1R4 and C1R3 mentioned that another complication as the inability to full fill the current electricity demand through the backup power sources (Generators) existing at the CEB power failures.

Moreover, C1R1 and C1R3 mentioned a complication of obtaining of finance approval for the maintenance work due to the unnecessary time consuming for the approval procedure and impact to have delays in some maintenance works.

All respondents involved to interviews identified that several property damages by the public, loss of items in public and common areas and changing of the decisions taken by top management time to time as other common complications in Case 1.

4.3.2 Maintenance Complications in the Case 2

C2 was a private building and occupying the own staff. Three numbers of respondents have involved providing details for the semi structured interviews. (Refer Table 4-2)

As per the experience of the C2R1, explained that he is not having much Maintenance complication within his job role. However, C2R1stated one of complications that faced as staff complains on system breakdown and the difficulty of conducting the maintenance work during the working hours as the staff of tenants deal with their core business. C2R2 and C2R3 also explained the same complications as mentioned by C2R1. In addition to that C2R2 and C2R3 stated another complication as the water leakages through the cracks in structural damage during the rainy season.

4.3.3 Maintenance Complications in the Case 3

In Case 3 building occupied own and tenant staff, three numbers of officers involved for the interviews including one from top management.

C3R1 respondent explained that minimum complications faced within his job duties. However, C3R1 stated one of the complications as tenants complains and requests. C3R2 and C3R3 also stated that there are minimum complications during their job task and further stated another complication as authority level to carry out some

urgent maintenance work. C3R3 explained that there is another complication of conduct of maintenance work at tenant area during office hours.

4.3.4. Maintenance Complications in the Case 4

Case 4building was a special case because the respondents involved for the interviews, explained minimum number of complications. C4R1 mentioned the officer complains on system breakdowns as a complication of maintenance in the building. C4R1 did not explain a cause as system malfunction can be occurred any time and stated that the company maintained the systems properly. However,C4R2 explained that attending to break down of the system during operation hour of the building as a complication, C4R3 also explained the same opinions as explained by C4R1. Further C4R1 mentioned the following reasons for the minimum complications of maintenance in the building.

- Good attention of the service providers at the breakdown of the systems and immediate rectifications.
- Knowledge of the technical staff
- Type of the occupancy
- Well Design and the Consideration the operations of the building at the design stage.
- The building has been designed toward to intelligent building concepts.
- Security condition of the building through the access control system

4.3.5. Maintenance Complications in the Case 5

This building occupying the government tenants and four (04) numbers of officers were involved to present their experience for the case study. (C5R1, C5R2, C5R3 and C5R4)

C5R1 explained that he is facing lot of complications during his duties. The interviewee mentioned that finance approvals of top management for the maintenance work as the major complication and due to that inability of attending and rectifying most of the breakdowns on time.C1R1 explained that another issue as spend more time for the approval processes and the procurements. Further C5R1

mentioned the authority level to carry out some urgent maintenance work as another complication, according to that the maintenance division has to delay the rectifications of some urgent work. C5R2 and C5R3 explained that they need to get the air conditioning consumption for the separate tenants' area however it is unable to obtain the reading being the unavailability of the BTU meters separately. Accordingly, they face difficulties when arranging the electricity bills for the tenants. Similar to Case1, C5R2, C5R3 and C5R4 also explained that most of the tenants are conducting their internal arrangements/modifications, data wirings without informing to the Maintenance division. Accordingly, it has generated complication of maintenance more and more errors in the systems like electricity distributions and air conditioning systems. Further C5R4 mentioned that they are unable to rectify the breakdowns on time and attend on time for the tenant complains. All the respondents involved inCase5 explained another complication as the some property damages, loss of items in public and common areas as massive of public due to visiting this building and it is difficult to manage the security of the building each and everywhere.

4.4 Causes affected for the Complications of Maintenance in Commercial buildings

As per the elaborated complications through five (05) cases there were different types of complications, some are common complications and the unique complications. Accordingly, this section presenting the causes affected for the identified complications of maintenance in section 4.4, as given by the interviews.

4.4.1. Causes affected for the Complications of Maintenance in Case 1

According to the complication of unable to obtain the separate energy consumption separate tenant area, which mentioned by C1R1 explained the cause for that complication is non-availability of separate energy meters installed at separate tenant area. Further C1R1 stated that unable to attend on time to rectify the break downs is the cause for the complication of tenant complains. The complication of improper space planning mentioned by the C1R1 stated the cause for this complication as difficulty of controlling the internal arrangement/ modification of the tenant areas.

In addition, C1R1 and C1R3 stated that inadequate budget allocation as the cause for complication of obtaining of finance approval for the maintenance work. On the other hand, C1R3 and C1R4 mentioned that absence of backup power system match with the current demand as the cause for the complication of unable to provide continues power supply to the building during the CEB power failure.

Further C1R2, C1R3 and C1R4 stated that difficult to obtain the permission for carry out the maintenance work during the office hours as the cause for the complication of conduct of maintenance work at the tenant areas.

The entire respondents in Case 1 stated that public usage and theft identified as the complication of property damages and losses.

4.4.2. Causes affected for the Complications of Maintenance in Case 2

Similarly to theCase1 C2R1 and C2R2 mentioned the difficulty of getting permission from tenants to conduct the maintenance work during the office working hours as the cause for the complication of conduct of maintenance work at the tenant areas.

Further, C2R1, C2R2 and C2R3 explained that crack and Damages as the cause for the complication of the rectification of the water leakage.

4.4.3. Causes affected for the Complications of Maintenance in Case 3

This case had minimum complication of maintenance. Similarly to the status of Case 1, C3R1 also mentioned that difficult to obtain the permission to carry out the maintenance work during the office hour as the cause for the complication of conduct of maintenance work at tenant area.

C3R2 and C3R3 explained that regulatory restriction as the cause for the complication of the authority level to carry out some urgent maintenance work.

4.4.4. Causes affected for the Complications of Maintenance in Case 4

Similarly, to the Case 3, this case also had minimum complications. C4R1 and C4R3 mentioned that unable to attend on time to rectify the issue as the cause for the complication of tenant complains about the system break down.

Similarly to Case 1, Case 2 and Case 3, C4R2 mentioned that difficult to obtain the permission to carry out the maintenance work during the office hour as the cause for the complication of conduct of maintenance work at tenant area.

4.4.5. Causes affected for the Complications of Maintenance in Case 5

Case 5 had more complications compare to Case 2, Case 3 as well as Case 4. C5R1 explained that inadequate budget allocation as the cause for the complication with finance approvals of top management for the maintenance work. Further C5R1 mentioned that unable to attend & rectify most of the breakdowns on time as a cause for the tenant complain about system breakdown. Similarly to Case 3, C5R1 explained that regulatory restriction as the cause for the complication of the authority level to carry out some urgent maintenance work.

C5R2 and C5R3 explained that unavailability of BTU meters in tenant areas as the cause for the complication of unable to obtain the BTU usage. Similarly to Case1, C5R2, C5R3 and C5R4 also explained that difficulty of controlling the internal arrangement/ modification of the tenant areas as the cause for the improper space planning.

C5R4 mentioned that unable to rectify the breakdowns on time as the cause for the complication of tenant complains about system breakdowns.

Similarly, to Case 1, all respondents involved in Case 5 also explained that public usage and theft as the main causes for the complication of some property damages, loss of items in public and common areas.

4.5. Factors affected for the Complications

As identified there were different types of factors that were affected for the complications and causes. According to the respondents in each case explained the factors for the complications and described case by case.

4.5.1. Factors affected for the Complications of Case 1

C1R1 explained that most of the complications such as unable to obtain the separate energy consumption for separated tenant areas, unable to provide the continues power supply to the building during the CEB power failure were occurred due to the consideration of the maintainability at design stage and unavailability of a maintenance officer in the project team. This is further justified by the respondents of C1R2 and C1R3 and further the respondents highlighted that unavailability of O&M

officer in project team as another factor affected for the complication. Further to that C1R2 and C1R3 mentioned that less commitment of the management and the capacity of the technical staff as other factors for the complications and the causes. All respondent explained that Security level of the premises is the factor for the property damages and losses. In addition to thatC1R4 explained that bad behavior of the public and lack of supervision of the technical staff as other factors that effected for the complication of property damages and losses.

All respondents of Case 1 stated that less commitment of the management, knowledge of the technical staff were the factors affected for the complication of tenant complain for the system breakdown.C1R1 mentioned that an additional factor for the complication of tenant complain for the system breakdown as inadequate budget allocation for the maintenance work.

Further respondents of C1R1, C1R2 and C1R3 in Case 1 explained that the factors affected for the improper space planning as unauthorized modifications in tenant area, permission procedure of the management, security level of the premises. In addition to that C1R1 explained other factors as policies of the company, less supervision of the maintenance officers and not having the full control over the tenants.

Moreover, C1R1 and C1R3 explained that awareness of the top management and less commitment of the top management are the factors for the complication of obtaining of finance approval for the maintenance work.

All respondents explained that the factors affected for the complication of decision changes of the top management mainly due to frequent changes in the top management, awareness of the management and request of the tenants.

4.5.2. Factors affected for the Complications of Case 2

Similarly to Case 1, C2R1 also explained that policies of the company, less commitment of the tenants and approval of the officers were the factors for the complications of conduct of maintenance work at the tenant area. C2R2 and C2R3 mentioned the factors affected for the complication of rectification of water leakage

as structural damage, and structure not design correctly. In addition to that C2R3 mentioned that method of rectification of leakage is the other factor for the complication of rectification of water leakage.

4.5.3. Factors affected for the Complications of Case 3

Case 3 also had most common complication of tenant complain for the system breakdown and conduct of maintenance work at tenant area, according to the respondents of C3R1, explained the factors affected for the complication of tenant complain for the system breakdown as less commitment of the management and the capacity of the technical staff.

C3R3 mentioned that policies of the company, less commitment of the tenants and permission of the officers are the factors for the complication of conduct the maintenance work at office areas.

C3R2 and C3R3 mention that awareness of the top management, policies of the company are the factors for the complication of authority level to carry out urgent maintenance works. In addition to that C3R2 explained that other factor is less commitment of the top management.

4.5.4. Factors Effected for the Complications of Case 4

Case 4 had minimum numbers of complications and C4R1, C4R3 explained that capacity of the technical staff and lack of preventive maintenance were the factors for the tenant complain about the system breakdowns. C4R2 mentioned the affected factors for the complication of maintenance work of the tenant area as policies of the company, less commitment of the tenants and approval of the officers similarly to the case 2.

4.5.5. Factors Effected for the Complications of Case 5

Similarly to case 1, C5R1 explained that awareness of the top management and less commitment of the top management are the factors for the complication of obtaining of finance approval for the maintenance work.

C5R2, C5R3 explain the factors affected for the complication of unable to obtain the BTU usage of tenant area as it is not considered at the design stage, unavailability of Maintenance office in the project team, less commitment of the management and knowledge of the technical staff.

Further C5R2, C5R3 and C5R4 explained that the factors affected for the improper space planning as unauthorized modifications in tenant area, permission procedure of the management, security level of the premises, and policies of the company.

C5R4 mentioned that knowledge of the technical staff and less commitment of the management are the factors for the complication of tenant complains about the system breakdown.

Similarly to Case 1, all respondents in Case 5 explained that security level of the premises and bad behavior of the public are the factor for the property damages and losses.

4.6 Strategies to Mitigate the Complication of maintenance in Commercial Buildings

It has found that the complications of maintenance had occurred due to the different types of causes as described in the section 4.4. The interviewed respondents in each case explained the precautions that can be taken to mitigate the complications of maintenance and presented their opinion in this section

C1R1 presented the precautions that can be taken to mitigate the complications of maintenance as follows.

C1R1 stated that the operations of the building should be properly plan at the planning stage. The design team should be obtaining the opinion from the well experience maintenance officer. further C1R1 stated that building should be designed toward green and intelligent building concepts. The policies and procedures should be provided to the tenants from the initial stage of the operation of the building to get the full control of them, if they break any condition, the management can be implemented penalty. C1R1 mentioned a strategy of recruitment of the

knowledgeable technical staff to carry out the maintenance work and technical staff should be comprised with the required number of staff.

C2R2 provided the following strategies to mitigate the complications of maintenance as follows.

- Structural engineering works should be done correctly
- Mechanical, Electrical, Plumbing, Carpentry and Civil (MEPCC) designs should be approved by well experience O&M officers in the field.
- Maintenance Officers (Facilities Manager/Maintenance Manager) should be recruited at the construction stage.

Moreover, respondent C2R2 mentioned the following things as reasons for having minimum maintenance complications in the buildings.

- Well Design and the Consideration of the building operation at the design stage
- Project team shall comprise with the knowledgeable persons
- The building has been designed towards to intelligent building concepts
- Integrate knowledge of the technical staff and their experience from the initial stage of the building operation.

Further C3R1 stated that precautions can be taken to mitigate the complications of maintenance as follows.

- Timely updating of the systems.
- More frequent services of the systems and preventive maintenance.

Moreover, C3R1explained that reasons for minimum complications in the buildings as follows.

- Good maintenance planning
- Proper building design with the consideration of the building operations at the design stage.

- The building has been designed towards to intelligent building concepts.
- There are good knowledgeable technicians who are continuing from the initial stage of the building operation and commissioning.
- Security condition of the building.

Further, C5R1 explained that the following strategies which can be taken to mitigate the complications of maintenance.

- Consideration the operations of the building at the planning stage.
- The involvement of the well experience O&M officers should be obtained at the design stage.
- MEPCC designs should be approved by well experience O&M officers in the field.
- Common policies, procedures should be provided for the tenants to get the full control of them. (penalty can be charged)
- Building operation should be handed over to the O&M officers who are in the relevant field
- Recruitment of the knowledgeable technical staff
- Technical staff should be comprised with the required number of staff

4.7. Discussion of the findings

As per the discussion of the Five (05) cases, to identify the common complications and the inherent complication marked in Table 4-3 with relevant case for the complication and the respondents who explained the complication.

Table 4-3 Summary of the complications

No	Complication	Relevant Cases	Respondents	No. of Respondents
1	Unable to obtain the separate energy consumption for the separated tenant areas	Case 1	C1R1, C1R2, C1R3	3

2	Unable to provide the continues power supply to the building during the CEB power failure	Case 1	C1R4, C1R3	2
3	Unable to obtain the BTU usage of tenant areas	Case 5	C5R2, C5R3	2
4	Tenant Complications for the system breakdown	Case 1, case 2, Case 3, Case 4, Case 5	C1R2, C1R3, C2R1, C2R2, C2R3, C3R1, C4R1, C4R3, C5R4	9
5	Improper space planning	Case 1, Case 5	C1R1, C1R2, C1R3, C5R2, C5R3, C5R4	6
6	Property damages and losses	Case 1, Case 5	C1R1, C1R2, C1R3, C1R4, C5R1, C5R2, C5R3, C5R4	8
7	Conduct of maintenance work at the tenant areas	Case 1, Case 2, Case 3, Case 4	C1R2, C1R3, C1R4, C2R1, C2R2, C2R3, C3R3,C4R2,	8
8	Rectification of water leakage	Case 2	C2R2, C2R3	2
9	Decision changes of the top management	Case 1	C1R1, C1R2, C1R3, C1R4	4
10	Finance approval for maintenance works	Case1, Case 5	C1R1, C1R3, C5R1	3
11	Authority level to carry out urgent maintenance works	Case 3, Case 5	C3R2, C3R3, C5R1	3

According to Table 4-3, it has identified eleven (11) numbers of complications within the selected Five (05) cases. The complication of the Tenant Complains about the system breakdown was identified as the most common complication since Nine

(09) of the Seventeen (17) respondents had stated that complication. Further the complication of the Tenant Complains about the system breakdown had in the Five (05) cases.

The complications of the Property damages and losses and Conduct of maintenance work at the tenant areas were identified as the next most common complications in the commercial buildings since the Eight (08) of the Seventeen (17) respondents had stated that complications.

According to detail show in Table 4-3 below, three (03) complications can be identified as the general complications for the commercial buildings in Sri Lanka.

1. Improper space planning
2. Finance approval for maintenance works
3. Authority level to carry out urgent maintenance works

The following Four (04) numbers of complications were identified as the inherent complication since those are unique for relevant cases.

1. Unable to obtain the separate energy consumption for the separated tenant areas
2. Unable to provide the continues power supply to the building during the CEB power failure
3. Unable to obtain the BTU usage of tenant areas
4. Rectification of water leakage
5. Decision changes of the top management

According to the discussion of the cases, the respondents who mentioned the complication explained the cause for the complication and the effected factors for the complications respectively. Accordingly, Table 4-4 presented the analysis of the common complications and the inherent complications with the explained cause for the complications and the factors affected for the complications as per the findings of the research.

Table 4-4 Factors Affected for the Complications of Maintenance

No	Complication	Respondents	Factors Affected	Respondents who explained the factors	No of respondents
1	Unable to obtain the separate energy consumption for the separated tenant areas	C1R1, C1R2, C1R3	It is not considering at the design stage	C1R1,C1R2, C1R3	3
			Unavailability of O&M officer in project team	C1R1,C1R2, C1R3	3
			Less commitment of the management	C1R2, C1R3	2
			Knowledge of the technical staff	C1R2, C1R3	2
2	Unable to provide the continues power supply to the building during the CEB power failure	C1R4, C1R3	It is not considering at the design stage	C1R4, C1R3	2
			Unavailability of O&M officer in project team	C1R4, C1R3	2
			Less commitment of the management	C1R4, C1R3	2
			Knowledge of the technical staff	C1R3	1
3	Unable to obtain the BTU usage of tenant areas	C5R2, C5R3	It is not considering at the design stage	C5R2, C5R3	2
			Unavailability of O&M officer in project team	C5R2, C5R3	2
			Less commitment of the management	C5R2, C5R3	2
			Knowledge of the technical staff	C5R2, C5R3	2

No	Complication	Respondents	Factors Affected	Respondents who explained the factors	No of respondents
4	Tenant Complications for the system breakdown	C1R2, C1R3, C2R1, C2R2, C2R3, C3R1, C4R1, C4R3, C5R4	Less commitment of the management	C1R2, C1R3, C2R1, C2R2, C2R3, C3R1, , C4R3, C5R4	8
			Knowledge of the technical staff	C1R2, C1R3, C2R1, C2R2, C3R1, , C4R3, C5R4	7
			Capacity of the technical staff	C3R1, C4R1, C5R4	3
			Budget allocation	C1R1	1
			Lack of preventive maintenance	C4R1, C4R2	2
5	Improper space planning	C1R1, C1R2, C1R3, C5R2, C5R3, C5R4	Unauthorized modifications in the tenant area	C1R1, C1R2, C1R3, C5R2, C5R3, C5R4	6
			Permission procedure of the management	C1R1, C1R2, C1R3, C5R2, C5R3, C5R4	6
			Security level of the premises	C1R1, C1R2, C1R3, C5R2, C5R3, C5R4	6
			Policies/conditions in the tenant agreements	C1R1, C5R3	2
			Less supervision of the O&M staff	C1R1	1
			Not having full control over the tenant	C1R1	1

No	Complication	Respondents	Factors Affected	Respondents who explained the factors	No of respondents
6	Property damages and losses	C1R1, C1R2, C1R3, C1R4, C5R1, C5R2, C5R3, C5R4	Security level of the premises	C1R1, C1R2, C1R3, C1R4, C5R1, C5R2, C5R3, C5R4	8
			Bad behavior of the public	C1R4, C5R1, C5R2, C5R3, C5R4	5
			Lack of supervision of the technical staff	C1R4	1
7	Conduct of maintenance work at the tenant areas	C1R2, C1R3, C1R4, C2R1, C2R2, C2R3, C3R3,C4R2	It is difficult to obtain the permission	C1R2, C1R3, C1R4, C2R1, C2R2, C2R3, C3R3,C4R2	8
			Policies of the company	C2R1, C3R3, C4R2	3
			Less commitment of the tenants	C3R3, C4R2	2
8	Rectification of water leakage	C2R2, C2R3	Structural damage	C2R2, C2R3	2
			Structure not designed correctly	C2R2, C2R3	2
			method of rectification of leakages	C2R3	1
9	Decision changers of the top management	C1R1, C1R2, C1R3, C1R4	Frequent changes in the top management	C1R1, C1R2, C1R3, C1R4	4
			Awareness of the management	C1R1, C1R2, C1R3, C1R4	4
			Request of the tenants	C1R1, C1R2, C1R3, C1R4	4

No	Complication	Respondents	Factors Affected	Respondents who explained the factors	No of respondents
10	Finance approval for maintenance works	C4R1, C4R2, C5R1	Awareness of the management	C4R1, C4R2, C5R1	3
			Policies of the company	C4R1, C4R2, C5R1	3
			Less commitment of the top management	C5R1	1
11	Authority level to carry out urgent maintenance works	C3R2, C3R3, C5R1	Awareness of the management	C3R2, C3R3, C5R1	3
			Policies of the company	C3R2, C3R3, C5R1	3
			Less commitment of the top management	C5R1	1

Table 4-4 has identified the most affected factors and moderately affected factors for the complications as per the numbers of respondent elaborate the factors.

Accordingly, it is not considered at the design stage and unavailability of O&M officer in project team were the most affected factors for the complication of unable to obtain the separate energy consumption for the tenant areas since the all respondent (Three numbers) who mentioned this complication have sated. Further, to that less commitment of the management and knowledge of the technical staff has identified as moderate factors for the complication of unable to obtain the separate energy consumption for the tenant areas. (Refer to table 4-4)

It is not considering at the design stage, Unavailability of O&M officer in project team and less commitment of the management have identified as the most effected factors for the complication of unable to provide the continues power supply to the building during the CEB power failure and knowledge of the technical staff has identified as the moderate factor. (Refer to Table 4-4)

It is not considering at the design stage, Unavailability of O&M officer in project team, less commitment of the management and knowledge of the technical staff have identified as the most affected factors for the complication of Unable to obtain the BTU usage of tenant areas. (Refer to Table 4-4)

Five factors have been identified for the complication of the Tenant Complications for the system breakdown and most affected factors were less commitment of the management and knowledge of the technical staff. Moderate factors were Capacity of the technical staff, Budget allocation and Lack of preventive maintenance. (Refer to Table 4-4)

Unauthorized modifications in the tenant area, Permission procedure of the management and Security level of the premises have been identified as the most affected factors for the complication of improper space planning and Policies/conditions in the tenant agreements, less supervision of the O&M staff and not having the full control over the tenant were the moderately affected factors. (Refer to Table 4-4)

Three factors have identified for the complication of Property damages and losses. The most affected factor was Security level of the premises, moderately affected factors were Bad behavior of the public and lack of supervision of the technical staff.

The most affected factor was it is difficult to obtain the permission since Eight (08) numbers of respondent mentioned this factor and moderately affected factors were Policies of the company and less commitment of the tenants for the complication of conduct of maintenance work at the tenant areas. (Refer to Table 4-4)

Refer to Table 4-4 Three factors have identified for the complication of Rectification of water leakage. The most affected factors were Structural damage and Structure not designed correctly. moderately affected factors was method of rectification of leakages.

Frequent changes in the top management, Awareness of the management and Request of the tenants have been identified as the most affected factors for the complication of decision changers of the top management as per the details of Table 4-4

Awareness of the management and Policies of the company were identified as most affected factors for the complication of finance approval for maintenance works and moderately affected factor was less commitment of the top management.

Finally, three (03) factors have been identified for the complication of authority level to carry out urgent maintenance works. Awareness of the management and Policies of the company were most affected factors and less commitment of the top management was the moderately affected factor. (Refer to table 4-4)

As per the discussions of the selected Five (05) cases, Table 4-5 presented the summery of the complications, cause and the effected factors for the complication.

Table 4-5 Complications of Maintenance, Causes and Affected Factors

Complication	Cause	Reasons for the complication
Unable to obtain the separate energy consumption for separated tenant areas	Non availability of separate energy meters installed for the separate tenant's areas.	It is not considering at the design stage
		Unavailability of O&M officer in project team
		Less commitment of the management
		Knowledge of the technical staff
Unable to provide the continues power supply to the building during the CEB power failure	Absence of backup power system match with the current demand (Generator System)	It is not considering at the design stage
		Unavailability of O&M officer in project team
		Less commitment of the management
		Knowledge of the technical staff
Unable to obtain the BTU usage of tenant areas	Unavailability of BTU meters in tenant areas	Unavailability of O&M officer in project team
		Less commitment of the management
		Knowledge of the technical staff

Complication	Cause	Factors affected
Tenant Complains for the system breakdown	Unable to attend on time to rectify the issues	Less commitment of the management
		Knowledge of the technical staff
		Capacity of the technical staff
		Budget allocation
		Lack of preventive maintenance
Improper space planning	Difficult to control the internal arrangement/modifications of the tenant areas	Unauthorized modifications in the tenant area
		Permission procedure of the management
		Security level of the premises
		Policies/conditions in the tenant agreements
		Less supervision of the O&M staff
		Not having the full control over the tenant
Property damages and losses	Public usage and theft	Security level of the premises
		Bad behavior of the public
		Lack of supervision of the technical staff
Conduct of Maintenance work of the tenant area	Difficult to obtain the permission for maintenance at tenant areas during the office hours	It is difficult to obtain the permission
		Policies of the company
		Less commitment of the tenants

Complication	Cause	Factors affected
Rectification of water leakage	Tracks & damagers	Structural damage
		Structure not designed correctly
		method of rectification of leakages
Decision changers of the top management	Decision changers of the top management	Frequent changes in the top management
		Awareness of the management
		Request of the tenants
Finance approval for maintenance works	Inadequate budget allocation	Awareness of the management
		Policies of the company
		Less commitment of the top management
Authority level to carry out urgent maintenance works	Regulatory Restrictions	Awareness of the management
		Policies of the company
		Less commitment of the top management

4.8 Summary of the Strategies to Mitigate the Complications of Operation and Maintenance in Commercial Buildings in Sri Lanka

When analyzed the opinions of the respondents in the commercial buildings, it had identified that complications were occurred in the operation periods of a building mainly due to the issues of the Design stage and Operation Stage. Accordingly, the following strategies have been provided to mitigate the complications of O&M due to the issued of two stages.

4.8.1 Strategies to mitigate the errors of the design stage

It has noted that the well-designed buildings have minimum number of complications in the operation stage. Therefore, following strategies can provide to mitigate the complications arisen due to the designed errors.

- Consideration the operations of the building at the planning stage.
- The involvement of the well experience O&M officers at the design stage.
- The building should be designed toward green and intelligent building concepts.
- Structural engineering works should be done correctly.
- MEPCC designs should be approved by well experience O&M officers in the field.
- O&M Officers (Facility Manager/Maintenance Manager) should be recruited at the construction stage.
- Project team shall have with the knowledgeable persons.
- The building shall be designed toward to intelligent building concepts.
- Well Design and the Consideration the operations of the building at the design stage.

Above strategies will help to make well designed buildings which provide easy operation and maintenance accepts within the building operation stage. The buildings designed properly helps to sustainable plans, green concepts and also the cost-effective maintenance procedure of the buildings.

4.8.2 Strategies to mitigate the errors of the operation stage

Further it has identified most of the complications are arisen in the coordination of the management and the O&M staff. Accordingly following strategies can provide to mitigate the complications arisen due to the team of O&M during the operation stage as identified from the study.

- Recruitment of the knowledgeable technical staff
- Technical staff should be comprised with the required number of staff
- O&M Officers (Facility Manager/Maintenance Manager) should be recruited at the construction stage
- Knowledge of the technical staff and their experience from the initial stage of the building operation
- The building has been designed towards intelligent building concepts.
- There are good knowledgeable technicians who are continuing from the initial stage of the building operation and commissioning.
- Good attention of the service providers at the breakdown of the systems and immediate rectifications.

Apart from these facts it has noted that some complications are arisen in the policies procedures and the type of tenants. Accordingly following strategies can provide to mitigate such issues.

- Good maintenance planning
- Security condition of the building
- Good Attention of the service providers at the breakdown of the systems and immediate rectifications.
- Security condition of the building through the access control system
- Common policies, procedures should be provided for the tenants to get the full control of them. (penalty can be charged)
- Building operation should be handed over to the O&M officers who are in the relevant field

4.8 Chapter Summary

Chapter Four presented the data gathered through the semi structured interviews. Accordingly, the chapter explained the profile of the cases and details of the respondents. This chapter analyzed the data collected from interviews. Further it has identified the complications of maintenance and the reasons for those complications. Finally, this chapter provided the strategies to mitigate the complications of maintenance which could occur during the design stage and the operational stage of the commercial buildings.

CHAPTER FIVE

5. 0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The preceding chapter analyzed the findings discovered by the semi structured interviews and provided the strategies to mitigate the complications of O&M in commercial buildings in Sri Lanka. This chapter focuses on arriving at conclusions and recommendations through the analysis and discussion carried out in the previous chapter. Conclusions derived on the overall research problem are presented. Recommendations are provided based on the findings of this case study.

5.2 Conclusions

Operation and maintenance of the commercial buildings play a vital role to provide comfortable environmental for the occupancy in a buildings. Maintenance team has responsibility to conduct and implement the O&M procedures and methodologies to achieve their goals. However, most of the technical teams with professionals have to face the complications of Maintenance during their job tasks. Therefore this research was derived to provide strategies to mitigate the complication of Maintenance in commercial building in Sri Lanka.

The aim of this case study was to mitigate maintenance complications of physical systems of commercial buildings in Sri Lanka. Therefore, this research was mainly focused on the commercial building in Sri Lanka and has selected five (05) commercial building in Colombo area to conduct the research study. Accordingly, three (03) objectives were established to achieve the aim of this research.

5.2.1 Objective one: identify the current maintenance complications of the commercial buildings

The first objective of this research was to identify the current maintenance complications of the commercial buildings. Relevant to that, in literature synthesis and through the semi structured interviews has found the complications of maintenance issues of physical systems of commercial buildings. It has identified Eleven (11) numbers of maintenance

complications. Four (04) numbers of complications were identified as the inherent complication since those are unique for relevant cases.

5.2.2 Objective Two: Examine the causes and factors that affect on maintenance complications arise during the operation

The second objective of this research was to examine the causes and factors that effect on maintenance complications arise during the operation. Accordingly, different types of causes and factors identified as per the experience of the professionals and Maintenance staff in the selected buildings. Eleven (11) courses relate to Eleven (11) numbers of complications and most affected factors and moderately affected factors identified (Refer to Table 4-5)

5.2.3. Objective Three: Provide strategies to mitigate the maintenance complications of commercial buildings in Sri Lanka

The final objective of this study was to provide strategies to mitigate the maintenance complications of commercial buildings in Sri Lanka. Maintenance staffs including head of the maintenance division were selected for the interviews of this research since they had a well experience in the building O&M and wealth of knowledge. According to the opinions of them strategies were provided to mitigate the complications of maintenance of the commercial buildings in Sri Lanka. Strategies are provided in two categories as strategies to mitigate the errors due to lack of design and strategies to mitigate the errors in operation stage. As examples, Unable to obtain the electricity reading in separate tenant area has occurred due to the lack of design of the systems. Further complication of Conduct of maintenance work at tenant area has occurred due to the lack of policies provided for the tenant from the operation stage (Refer to Table 4-5)

5.3 Recommendations

This research has identified the complications of maintenance in commercial buildings in Sri Lanka, factors affecting for the complications and provided the strategies to mitigate the maintenance complications. During the research, it was identified that there were some factors affected for the complications which created due to the lack of consideration of operation and maintenance at the design stage. Therefore, it is recommended to obtain the opinion of O&M officer for the design concepts and system installations. There were

some complications occurred due to the issues of maintenance team. Accordingly it is recommended that the maintenance team should be comprised with knowledgeable staff to conduct the operation and maintenance of buildings. Further it was identified that some complications has occurred due to the top management issues, most of the top management may not consisted with the experts of O&M field, therefore the decision of them creates complications Maintenance. Accordingly recommends appointing a one of officer from O&M sector for the top management of buildings.

5.4 Study Limitations

This study limited to Five (5) cases in Colombo area and conducted the semi structured interviews for Seventeen numbers of respondents due to the time frames for the study.

5.5 Future Studies

This study can be expanded to the other category such as hotel sector, hospitality and Industrial.

This research can be further conducted for the overall operation of a building including janitorial services and health & safety.

This can be expanded for the different facilities available in the building in depth.

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7.0 APPENDIXES

APPENDIXES-1

INTERVIEW GUIDELINE

H.G.V Madusanka
Student of MSC in Project Management
Department of Building Economics
University of Moratuwa

Dear Sir/Madam,

Interview guideline for a dissertation on "Mitigating the complicated operation and maintenance of the commercial buildings in Sri Lanka"

I am a student of MSC in Project Management at the University of Moratuwa. I carry on my research under the topic which I have mentioned earlier and the interview is use to identify the current operation and maintenance complications in the building and causes that are affect to the complications. In follow I attached questions which I need to get above mentioned details

The interview guideline is prepared to fulfil the purpose of gathering information current operation and maintenance complications in the building and causes that are affect to the complications. I request from you to give a little bit your valuable time and comment your thoughts in my interview guideline. All the data I have collected only for my research purpose and this all data keep with me and will not give to any other party. The information provide will be treated which strict confidence and the result would be summarized and presented if you want. Thank you for giving your kind help by spending your valuable time. Thank you.

Yours' faithfully

H.G.V Madusanka
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CASE STUDY INTERVIEW GUIDE

MITIGATING MAINTENANCE COMPLICATIONS OF PHYSICAL SYSTEMS OF COMMERCIAL BUILDINGS IN SRI LANKA

Target Group: Maintenance Division

Section 1: Details of Respondent

1. Name of the respondent (Optional): ……..

   Designation: ……...

2. Please describe your involvement to this project? (i.e. Role and responsibility)

3. Experience in the operation and maintenance sector

   i. ☐ Less than 3 years

   ii. ☐ More than 3 years and less than 5years

   iii. ☐ More than 5 years and less than 10 years

   iv. ☐ More than 10 years

4. How long do you engage with the operation and maintenance in this building

Section 2: Description of the Building

Detail of the Building

Building Name and location	
Brief description about the building	
Age of the building	

Commencement Date of Building operation	
Construction period	
Expected life time of the building	
Types of Services available	
Type of occupants	

Building Maintenance and Operation

5. Does the building have a maintenance manual? And explain its purpose
6. What the complications of the building faced during the maintenance and operation period in terms of the following physical systems?

System	**Complications**
Electrical System	
Plumbing System	

HVAC system	
Fire protection	
Elevator System	
Security Systems	
Other Complications	

7. What the causes for such complications mentioned in Table …?

Complication	**Causes for Complications**

8. Can you provide the factors that are affected for the complications you already mentioned?

Complication	**Factor affected for Complications**

9. What the strategies can suggest for mitigate such complications

   .....

   .....

   .....

10. Do you have any additional opinion for the smooth operation and maintenance of a building?

    .....

    .....

    .....

APPENDIXES - 2

CASE STUDY INTERVIEW GUIDE- TRANSCRIPT

MITIGATING MAINTENANCE COMPLICATIONS OF PHYSICAL SYSTEMS OF COMMERCIAL BUILDINGS IN SRI LANKA

Target Group: Maintenance Division

Section 1: Details of Respondent

1. Name of the respondent (Optional): XXXXXX

   Designation: Director Engineering

2. Please describe your involvement to this project? *I did not involve in the construction period of this project but currently involve in the Building Operation and Maintenance division*

3. Experience in the operation and maintenance sector

   i. ☐ Less than 3 years

   ii. ☐ More than 3 years and less than 5years

   iii. ☐ More than 5 years and less than 10 years

   iv. ☒ More than 10 years

4. How long do you engage with the operation and maintenance in this building? *I have been engaging for 22 years at the O&M division*

Section 2: Description of the Building

Details of the Building

Building Name and location	Sethsiripaya Stage I
Brief description about the building	This is fully rented out for the government ministries and Organizations
Age of the building	33 Years
Commencement Date of Building operation	1986 November
Construction period	5 Years
Expected life time of the building	100 Years
Types of Services available	Office facilities including HVAC, Transportation, Lighting Facilities, MEPCC services, Janitorial services, Security Services, Fire Protection Systems , Parking Facilities
Type of occupants	Government

Building Maintenance and Operation

5. Does the building have a maintenance manual? And explain its purpose.

   Currently we don't have comprehensive maintenance manual for the operation and maintenance; however we use separate manuals for HVAC, Generator operation and Fire Protection system like wise

6. What are the complications of the building faced during the maintenance and operation period in terms of the following physical systems?

System	***Complications***
Electrical System	*As this building rented out for the tenants we need to collect the payment for Electricity Chargers, Water and the Building rent. However we are unable to measure the electricity consumptions for the tenant areas separately as there are no separate energy meters at separate tenant area, Accordingly it is a complication in electrical system. Tenants' complains for Electrical system break down can be stated as another complication.*
Plumbing System	*Currently not found any critical complications in the plumbing system*
HVAC system	*We have provided the fixed air conditioning systems as per the area allocated for the tenants, sometime tenants are conducting their internal space arrangement without informing to the maintenance management.*

	Accordingly there is complaining regarding the lack of Air conditioning facilities in some areas. Therefore one of the complications can be mentioned as improper space planning. *Other complains are system breakdowns. However most of the tenants are don't allow us to carry out some maintenance work in the tenant areas during the office hours.*
Fire protection	*Currently not found any complications*
Elevator System	*Not found any complications since the service provider conduct a proper (regular) maintenance plan for the elevator system*
Security Systems	*In the security condition of the building, we noted that there are some property damages and losses*.
Other Complications	*Another Important complication is the decision changes of the top management. As this building relevant to the government sector, top management members are changed time to time. Then most of the time, the decision taken by previous management has been changed by the newly appointed members. Therefore we are facing big difficulties due to that reasons.*

7. What the causes for such complications mentioned the above?

Complication	**Causes for Complications**
Unable to obtain the separate energy consumption for the separate tenant area	*Mainly this complication has occurred due to the unavailability of the separate energy meters for the separate tenant area.*
Tenant complains for the system break downs	*The cause for this complication is unable to attend on time to rectify the issues. Our maintenance team not aware about some system breakdown, accordingly we are unable to rectify the system until we receive complains from the tenants. Otherwise we have to take time to purchase some spare parts for rectifications.*
Improper space planning	*This complication has occurred due to the difficult to control the internal arrangement/modifications of the tenant areas without permission.*
Property damages and losses	*As this building occupied government ministries and organizations, there are huge public circulations therefore Public usage and theft is the cause for this complication*
Decision changes of the top management	*As usual the members of the top management change within two years. therefore Changes of the top management is the cause for this complication*

8. Can you provide the factors that are affected for the complications you already mentioned?

Complication	**Factor affected for Complications**
Unable to obtain the separate energy consumption for the separate tenant area	*According to my experience, Consideration of the design stage can be stated as a factor that affected for the complication, further unavailability of O&M officer in project team other factor that affected to create this complication*
Tenants complain for the system break downs	*Basically due to less commitment of the management and less knowledge of the technical staff*
Improper space planning	*I can stated many number of factors for improper space planning. Main reason is the unauthorized modifications in the tenant area, then lack of policy provided permission procedure of the management .* *other factors are Security level of the premises, Less supervision of the O&M staff and not having the full control over the tenant*
Property damages and losses	*If there is a strong security system, the public are unable to do damages and property losses. Therefore, security level of the premises is very important.* *On the other hand , bad behavior of the public and lack of supervision of the technical staff are also affect on property damages*

Decision changes of the top management	As stated earlier, main reason is frequent changes in the top management, awareness of the management and request of the tenants

9. What the strategies can suggest for mitigate such complications?

According to my experience, most of the complications occurred due to the lack of design of the building and the services. Therefore, my opinion is the function of the building and maintainability should be considered at the design stage. Accordingly there should be well knowledgeable persons to obtain the opinion on the maintenance as such it is a strategy that get involvement of a knowledgeable maintenance officer at the design stage.

Now building can manage through the computerized system therefore building should be designed toward green and intelligent building concepts.
After stating the operations of a building, there should have a fully control of the tenant accordingly the management should prepare a proper policies and procedures or agreement. If they break any condition, the management can be implemented penalty. Otherwise during the operation the building maintenance team should recruit a knowledgeable technical staff to carry out the maintenance work and technical staff should be comprised with the required number of staff.

10. Do you have any additional opinion for the smooth operation and maintenance of a building?

For the smooth operation of a building, personally I believed, the top management also should comprise with general knowledgeable persons regarding the maintenance. Good maintenance plans should be implemented for preventive and the corrective maintenance.

Thank you.