ASSESSMENT OF IMPACT OF LATENT DEFECTS IN CONDOMINIUMS IN SRI LANKA

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ABSTRACT

Condominiums have become the most predominant and popular form of residential development and identified as an ideal solution to the ever increasing housing demand in Sri lanka. However, latent defects are considered as one of the recurring problems in condominiums and have adverse effects on condominiums' performance and occupants or end-user satisfaction. The lack of focus on latent defects leads to negative impacts on cost, time and quality of condominiums. In view of that, this research aims to assess the impact in terms of frequency of occurrence, severity and rework/rectification cost of latent defects in condominiums in Sri Lanka.

A survey research strategy was employed in the current study, quantitative research approach. The questionnaire designed based on the knowledge gained through literature was distributed to occupants of condominiums. The collected data was analysed by using descriptive statistical analysis such as mean weighted rating to accomplish the research aim.

Questionnaire findings identified nineteen types of latent defects which were experienced by occupants of condominiums. Further, in order to assess the impact of latent defects in condominiums, questionnaire findings recognised that water seepage was the most frequently occurred latent defects while cracks and stains were higher severity latent defects and cracks required the highest rework/rectification cost. Moreover, external wall has been developed the highest frequency of latent defect in condominiums. Eventually, water seepage, cracks, functioning defects in service equipment and pipe leaking were recognised as having a significant impact in terms of frequency of occurrence, severity and rework/rectification cost of latent defects. Moreover, use of poor quality construction materials, faults during the construction, faults during the design and lack of maintenance in condominiums were identified as significant human causes where the focus should be laid upon in mitigating latent defects.

Thus, this research provides inputs to the occupants, maintenance professionals, condominium management and construction professionals on assessing impacts of latent defects in order to effectively mitigate the latent defects in condominiums in Sri Lanka.

Key words: Condominiums, Latent defects, frequency of occurrence, severity, rework/rectification cost.

DEDICATION…..

TO MY BELOVED FAMILY

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LIST OF ABBREVIATIONS

ASR	Alkali-Silica Reaction
CIB	International Conference on Building Education and Research
CMA	Condominium Management Authority
DLP	Defects Liability Period
MDF	Medium Density Fiberboard
MEP	Mechanical Electrical and Plumbing
MWR	Mean Weighted Rating
Qi	Question number
UK	United Kingdom

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Major cities are increasingly being developed in Asia, where the shortage of land due to rapid urbanization needs a high-density and high-rise type residential development (Yip & Forest, 2002). Moreover, the growing fame of occupant ownership in last few decades has been created the condominiums as the supreme popular and prevalent type of development in residential (Yip, Chang, & Hung, 2007) as well as condominium is a western lifestyle introduced to the urban region of the eastern countries due the growing population density and the scarcity of serviced land (Siniti, 1990).

The word "condominium" is a combination of two Latin terms and it comprises structures for living commonality and individually (Edirimane, 2006). Also Kowshala (2002) defined condominium as structure or building of two or more units, the internal area of each unit owned individually and balance premises owned commonly by individual unit owners. Moreover, condominiums provide their occupants with more safer and secure environment compared to other type of housing and this has been the key reason why many people move into condominium housings in Sri Lankan (Edirimane, 2006). Also condominiums have become a solution for urban migration among all income levels in Sri lanka (Dias, 2017). However, condominiums are experiencing maintainability issues and a large number of defects during the occupancy (De Silva & Ranasinghe, 2010).

Building failures and defects are common phenomena in constructions either civil engineering or building (Ransom, 1995). Various authors have been differently defined the word 'defect'. The defect means the shortcomings in the construction and design practices and it indicates the insufficiencies which occur from normal tear and wear. Due to poor labour practices, poor materials and faulty construction methods, design and construction defects are arisen (Olanrewaju et al., 2010). Similarly,

Douglas and Ransom (2013) depicted that defects are the shortcoming in performances of the building or element or product that arise in any time in life. Also it comes from requirements of designs that are not considered themselves as errors.

Usually, building defect occurs through tear and wear. Wear and tear means reduction or depreciation or falls the value of a building and services or functional performance due to the fair or normal usage as well as it can be occurred due to the natural weather conditions or age of the building and services or combination of these (Olanrewaju et al., 2010). The main sources of building defects are remedial works and poor maintenance or inappropriate use, mismanagement, pollution, human intervention, other natural hazards, geochemical, meteorological and biological (Watt, 1999). Further, Rushton (2009) identified three main causes such as biological or chemical changes, movements and dampness. Moreover, most of the defects arise over external factors on building materials including main components air or rain water, moisture, solar radiation, weather and gaseous and solid contaminants, salt or ground water, corrosion, particular fungi attacks and biological agencies (Ransom, 1995).

There are some common types of defects including structural defects such as collapse or cracks, faulty drainage system, plumbing defects, defects in lighting and electrical wiring, insufficient suppression or fire protection system and insufficient sound proofing or insulation, vermin infestation or termite, fungus, mold, wood rot and dry rot (Ahzahar, Karim, Hassan, & Eman, 2011).

The defects can be differently named as construction defect, handover defect, post-handover defect and latent defect according to the phase when the defects occur (Forcada, Macarulla, Gangolells, & Casals, 2015). Construction defects are defined as defects occur during the construction phase (Forcada, Macarulla, Gangolells, & Casals, 2014) and latent defects are defined as defects appear during building occupancy (Chong & Low, 2006). Similarly, Rhodes and Smallwood (2002) categorized the defects as patent defect as well as latent defect. Patent defects are observed visually during the construction phase as well as Defects Liability Period.

but latent defects are hidden defect and become visible at later stage and that will appear once the buildings are occupied (Isa, 2011).

However, according to existing quality standards, structural defects can be rectified during construction stage as well as functional defects and aesthetic defects retain and appear after handed over. These defects are rectified after the complaints of the occupants (Forcada, Macarulla, Gangolells, & Casals, 2015). There are some defects such as chip off, efflorescence, discolored tiles, hollowness, stains, unevenness, delaminated tiles, water seepage and cracks occur at occupancy stage in most of the buildings (Chong & Low, 2005). Moreover, there are some defects such as water leakage, water stagnation, spalling, rain penetration, blocking channel and gutter, discoloration, water penetration, spill soffit, corrosion of reinforcement, growing of mosses, fungi and weeds, cracks, breaking drainage pipes occur in condominiums (Wijesinghe, 2005). Accordingly, latent defects became a terrible thing to some of potential purchaser of condominium (Edirimane, 2006). Occupancy stage defects primarily affect the aesthetic appearance of the condominiums and stability of the structures (Wijesinghe, 2005).

Design error is commonly made and contractors usually try save the construction cost during the construction stage. Subsequently, this causes the defects over time (Ahzahar et al., 2011). Moreover, the cost of defects that occur at construction stage is 2-6% of the construction cost as well as the cost of defects that arise at maintenance stage or occupancy stage is 3-5% of construction cost (Josephson & Hammarlund, 1999). The rectification cost of defects decrease the profit of the contractor and the construction organization. Moreover, latent defects in building decrease the satisfaction of customers and damage the builder's reputation (Forcada, Macarulla, & Love, 2013). More consideration is necessary for maintenance work and frequent repair work in condominiums (Sulochana, 2007). However, repetition of latent defects can be avoided or prevented through correcting or eliminating the root causes (Josephson, 1998) as well as remedial strategies have to be established in short-terms and in long-term to detect and eliminate the latent defects throughout the life cycle of the condominiums (De Silva, Sampath, & De Silva, 2015).

1.2 Problem Statement

The concept of condominiums has become the most popular and prevalent in the development of residential (Yip et al., 2007) since the condominiums play an important role in the economy of Sri Lanka (Senaratne, Zainudeen, & Weddikkara, 2006). However, defects play significant role and impact negatively in condominiums (Sulochana, 2007). Many systems have been used to effectively detect and eliminate the defects that occur during the construction process. However, numerous complaints about defects have been reported by occupants after building occupied or after few years. It was exposed that "there are still loopholes in the existing systems to detect and eliminate the occupancy phase defects" (Chong & Low, 2005). Moreover, De Silva and Ranasinghe (2010) depicted that there was no proper test systems or evaluation mechanisms for defects and maintainability at the occupancy stage in condominiums in Sri Lanka. Even though buyers paid high price to purchase a condominium in Sri lanka, they have failed to detect and eliminate the latent defects unless they have a background in civil engineering or a specialized knowledge in building works (Edirimane, 2015). However, there seems latent defects are prevalent and impact the occupants of condominiums. This general fact led the researcher to explore further and to address the problem of '*what are types of latent defects impacts in terms of frequency of occurrence, severity and rework cost, causes and remedial measures available to effectively mitigate the latent defects in condominiums?*.

1.3 Aim and Objectives

The aim of this study is to assess the impact of latent defects in condominiums in Sri Lanka.

Following objectives were established, in order to achieve the aim of this research.

1. Review the types of latent defects pertaining to condominiums.
2. Assess the impact of latent defects in terms of frequency of occurrence, severity, and rework/rectification cost in condominiums.
3. Identify the causes of latent defects in condominiums.
4. Explore the measures to be taken to mitigate latent defects in condominiums.

1.4 Methodology

An in-depth literature review was done through electronic media, research paper, articles, journals and books in order to establish the current knowledge base regarding the significance of condominiums, types of latent defects, causes of defects, effects and rework cost of latent defects in condominiums. Initially, a pilot questionnaire survey was carried out among randomly selected five occupants including members of condominium management to ensure that the data to be collected would enable the achievement of the research aim. A detailed questionnaire survey was carried out among thirty six occupants of condominiums to obtain views of impact of latent defects in terms of frequency of occurrence, severity and rework/rectification cost, causes to latent defects and remedial measures to mitigate the latent defects and other issues in condominiums. The data gathered through questionnaire survey was analysed by calculating mean weighted rating.

1.5 Scope and Limitation

The scope of the study focused on defects which occur during operational phase, after the defects maintenance period of a building and the data collection was limited to 0-20 years aged semi-luxury condominiums which are located in the Colombo metropolitan area. Further, the defects were considered from the perspective of occupants of the condominiums.

1.6 Chapter Breakdown

Chapter I This chapter describes the background of the research, problem statement, aim, objectives, methodology, scope and limitations of the study.

Chapter II This chapter extensively discusses about existing literature on condominiums, theoretical background to building defects, defect types, causes and effects of latent defects on condominiums.

Chapter III This chapter explains about the methodology to be used in order to analyse the collected data from questionnaire and analysis together with the justification for using the particular research approach.

Chapter IV This chapter presents the statistical analysis of impact of latent defects regarding frequency of occurrence, severity and rework cost and frequency of latent defects in condominium elements as well as causes of latent defects and remedial measures to mitigate the latent defects.

Chapter V This chapter concludes from the research analysis with recommendations for the research and the identification of further research areas.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

A preliminary survey presented that the literature relevant to condominiums and defects originate from various countries. This shows an important challenge to this research in terms of adequately conceptualizing the work in Sri Lanka. Therefore, this chapter makes it out the concept of condominium and gradually tries to recognize the different types of defects in buildings. After that, reviews the types of latent defects in condominiums, causes of latent defects, effects and rework cost of latent defects and remedial measures to mitigate the latent defects in condominiums. Finally, the chapter is ended with the establishment of the knowledge gap.

2.2 Concept of Condominium

The concept of condominiums became as an ideal solution to ever increasing housing demand which is generated by growing population and economic growth. The word "condominium" is obtained from Latin term "condo" that means to put or joins together (Ranaweera, 2006). Since "condominium" is a combination of two Latin terms and it comprises structures for living commonality and individually (Edirimane, 2006). The oxford dictionary (2012) defined condominium as building or complex in which units of property such as building structures and premises are jointly owned by owners of the unit. Further, Common Amenities Board (2003) declared that condominium as any building or buildings having two or more stories on isolated land, considered as single land capable being sectioned into units and to any buildings having only one storey on the same land of being subdivided into parcels. Similarly, Apartment ownership act no 11 of 1973 in Sri Lanka depicted the condominium as premises containing land and buildings or building of more than single storey and consisting more than single independent unit of non-residential or residential accommodation (Ministry of Justice and Judicial Reforms, 1982).

However, Lee (2005) stated that condominium is an individual unit that is owned (or can be owned) separately from the other units in the condominiums. Kowshala (2002) defined condominium as structure or building of two or more units, the internal area of each unit owned individually and balance premises owned commonly by individual unit owners. Subsequently, Tracht (1999) stated that occupants in condominiums have equal right to use open areas in condominiums such as swimming pool, elevator, lobby, escalator, Vehicle Park, playing area and other open places. By considering all definitions condominium can be defined as a building or structure which is having two or more stories, sub divided into many units built on alienated land and internal area of each unit owned individually and balance premises owned commonly by individual unit owners. In Sri lanka, with the demand increasing for housing in the urban areas such as Colombo and Kandy, it can be seen a surge in the construction of condominium properties (De Silva & Ranasinghe, 2010). Moreover, the latest trend in vertical living is gaining popularity across all income levels as evident in the evolving Colombo skyline (Dias, 2017).

2.2.1 Significance of Condominiums in Sri Lanka

The growing popularity of ownership has made condominium as the most popular and prevalent type of residential construction in the last few decades (Yip et al., 2007). Condominiums provide their occupants with more safer and secure environment compared to other type of housing and this has been the key reason why many people move into condominium housings in Sri Lankan (Edirimane, 2006). Moreover, Senaratne et at., (2006) stated that there is a considerable demand for condominium in Sri Lanka due to shortage of land in metropolitan area of Colombo and the convenience of purchasing a condominium instead of building a house.

Customers have been encouraged to purchase condominiums due to various aspects such as aesthetic appearance, affordable price instead of purchasing a land and building a house in that location, modern facilities, good location with easy movement to city centers, secure parking facilities, prestige value, flexible payment methods given by the contractors, peaceful and secured neighborhoods (Senarathne et al., 2006). Compared to owners of individual houses, owners of condominium

units have lower costs as they share the common areas in condominiums (Edirimane, 2006). Further, condominium accessibility is more significant for consumers and individual owners pay less cost for common facilities such as garbage removal, recreation facilities and security services (Putri, Setijanti, & Faqih, 2016). Moreover, author stated that it is necessary to locate in the center of city in order to move easily to important places such as shopping centers, work places, hospitals and schools and other public facilities as well as the location near to city center must guarantee the profitable investment and secure. However, with the infrastructure development in the island, there is a positive incline in supply and demand for different types of condominiums.

2.2.2 Types of Condominiums

Condominiums can be refurbished apartments or town houses or commercial ware houses (Wimalarathna, 2005). There are new condominium developments such as lease hold condominiums, phased condominiums, free hold condominiums, common element condominiums, retirement condominiums and vacant land condominiums (Clifton, 2007). Common Amenities Board Act No 24 of 2003 categorized the condominiums into four such as industrial, commercial, residential and mixed use. However, Wijeyeweera (2004) researched that residential condominiums have the highest demand in Sri Lanka and it can be divided as super luxury condominiums, luxury condominiums, semi-luxury condominiums and utility condominiums.

- **Super Luxury Condominium**

These types of condominiums mainly occupied by foreigners or upper or upper middle class income groups in Sri Lanka. Most of these apartments are located in prestigious area (Kajaraj, 2006). The market is quite politically sensitive and may get saturated taking into account that expatriated community is limited. These condominiums can be grouped as super luxury when it has following facilities and modern techniques such as gymnasium, highly sensitive electronic security system, fire alarm system, swimming pool and restaurant (Ranaweera, 2006).

- **Luxury Condominium**

These types of condominiums are mainly to cater to the upper or upper middle class income groups in Sri Lanka and normally the price range of these apartments is less than super luxury condominiums (Kajaraj, 2006). The facilities of luxury condominiums consists central gas supply system, gymnasium, laundry, restaurant and bars, swimming pool and air conditioned apartment etc. Consist of the all modern techniques, requirements which are comparatively less expensive in the super luxury condominiums (Ranaweera, 2006).

- **Semi Luxury Condominium**

Semi-luxury condominiums have come up primarily in zones where the land values are relatively cheaper. This category demand is high to a market driven by needs. Semi-luxury condominiums are becoming prevalent among migrant workers who can purchase these units by using their foreign earnings and peacefully live on their retirement (Wijeyeweere, 2004). These condominiums equal to normal houses. Fittings and finishes are not that much expensive than luxury condominiums and facilities such as elevators, children's play areas, private balconies, garbage disposal system, vehicle Park are provided (Sampath, 2011).

- **Utility Condominium**

The Government is the key developer of utility condominiums in Sri Lanka. The beneficiaries of that government sponsored projects are shanty dwellers, low income earners and government officials. Mostly, these condominiums have been built by government in Colombo as urban regeneration programmes and resettlements (Wijeyeweere, 2004).

In addition to above categories, Senaratne et al., (2006) stated that types of condominium available in Sri Lanka are categorized into super luxury, luxury and semi luxury depending on the level of availability of facilities. Table 2.1 shows below the types of condominium and the available facilities.

Table 2.1: Types and Facilities of Condominiums

Facilities	Types		
24 hours security	Super Luxury Condominium	Luxury Condominium	Semi Luxury Condominium
CCTV & Intercom System with panic button for emergencies			
Fire Protection and Detection System			
Garbage Disposal Systems			
Elevators			
Hot water Geysers			
MATV Connection			
Children's Play area			
Vehicle Park			
Private Balconies			
Air conditioned Apartment blocks			
Swimming pool			
Restaurant and Bar			
Gymnasium			
Laundry			
Central Gas supply system			
Children's Pool			
Games Room			
Convenience Stores			
Video Centre			
Changing and meal room for drivers			
Walking Track			
Squash Court			
Salon			
Sauna			
Standby Generator			
Service Elevator			
Three-tier security system			

Source: (Senaratne et al., 2006)

Ultimately, in this research, residential type condominiums such as super luxury condominiums, luxury condominiums, semi-luxury condominiums are concerned. Although the condominium provides their occupants with a safer and more secure environment compared to other type of homes, increasing defects became a terrible thing to some of potential purchaser of condominium in Sri Lanka (Edirimane, 2006). Similarly, De Silva and Ranasinghe (2010) depicted that the condominiums are experiencing maintainability issues and a large number of defects during the occupancy.

2.3 Defects in Building Construction

Defects are common phenomena in construction industry. Most of the building defects can be avoided: they generally occur due to misapplication or non-application of it but not due to lack of proper knowledge (Douglas & Ransom , 2013). Various authors have been differently defined the word 'defect'. The defect means the shortcomings in the construction and design practices and it indicates the insufficiencies which occur from normal tear and wear. Due to poor labour practices, poor materials and faulty construction methods, design and construction defects are arisen (Olanrewaju et al., 2010). Further, building defects are described as shortcoming or failing in user requirements, statutory, performance and function of the building and occur within facilities, fabric, structure or other services of the damaged building (Watt, 1999). Similarly, Douglas and Ransom (2013) depicted as defects are the shortcoming in performances of the building or element or product that arise in any time in life. Also it comes from requirements of designs that are not considered themselves as errors. Pheng and Wee (2001) defined the building defect as shortcoming or failure in facilities, fabric, services, user requirement of structures, statutory, function and performance.

It is important to exactly explain the meaning of defects and the various terms that use in construction management literature. Defects can be interchangeably used with snags, rework, non-conformance, quality deviations, quality failures, repairs and construction faults (Abdul-Rahman, 1995). Normally, snags are described as quality failure stuffs that can be recognised during the completion phase of constructions by

the person who is called as the snag identifier as well as rectifying and identifying process of these snags is termed as direct reporting or snagging (Sommerville, Craig, & Bowden, 2004).

Usually, building defect occurs through tear and wear. Wear and tear means reduction or depreciation or falls the value of a building and services or functional performance due to the fair or normal usage as well as it can be occurred due to the natural weather conditions or age of the building and services or combination of these (Olanrewaju et al., 2010). Moreover, defects occur due to wrong installation and use of design by the contractor, defective materials, manufacturing faults and design faults by professionals (Ahzahar et al., 2010). Similarly, Hopkin and Lu (2015) exposed defects occur due to inadequate consideration given to building maintenance and poor or inappropriate construction, specification and design as well as tropical climate conditions. Anand, Vasudevan and Ramamurthy (2003) highlighted that most of the defects are visible during the occupancy stage and they are not seemed during the construction stage.

2.3.1 Types of Defects

The defects can be differently named as construction defect, handover defect, post-handover defect and latent defect according to the phase when the defects occur (Forcada et al., 2015). Construction defects are defined as defects occur during the construction phase (Forcada et al., 2014). Handover defects called as 'snags' in UK, are defined as defects are discovered during the construction operations and these are usually rectified before partial completion or these are "visible" to the developer or house purchaser once the house is considered ready for occupancy (Sommerville & MoCosh, 2006). Post-handover defects are defined as defects remain after building has been handed over but only during the 12-months liability period (Forcada et al., 2013). Latent defects are defined as defects appear during building occupancy (Chong & Low, 2006).

Furthermore, Rotini, Tookey and Rotini (2015) classified the defects in residential buildings as absorbed defects and visible defects. Absorbed defects are detected

during the construction stage and visible defects are detected during the occupancy stage. Similarly, Rhodes and Smallwood (2002) categorized the defects as patent defects and latent defects.

2.3.1.1 Patent Defects

Patent defects are 'obvious' defects that are detected during the construction process as well as Defects Liability Period (Chong & Low, 2006). Patent defects can be visually observed (Isa, 2011). Moreover, author described that patent defects are always reported in the defect lists or snagging during the practical completion. Although these defects are not visible at partial completion, these become visible soon after. If these defects are patentable during the rectification process, most of the standard building contracts consists mechanisms to rectify these defects.

2.3.1.2 Latent Defects

Latent defects are hidden defects and become visible at later stage and that will appear once the buildings are occupied (Isa, 2011). Commonly, latent defects can be categorised under each building elements such as foundation, wall, floor, basement, doors and windows, roof, cladding, services and etc (Ransom, 1995). However, eliminating latent building defects is a difficult task. Latent defects are difficult to identify because of the time frame such defects appear. Unless these defects are became sufficiently severe to cause occupants to complain, most of such defects are rarely appeared to public (Chong & Low, 2005). Moreover, most of these defects are detected by occupants or end users during the occupancy phase as aesthetic defects or omissions and technical defects (Sommerville & MoCosh, 2006). A history of such latent defects in a condominium property, will invariably depress its property value even if it is located in a good residential area (Edirimane, 2006).

2.4 Latent Defects in Condominiums

Occupancy stage defects primarily affect the aesthetic appearance of the condominiums and stability of the structures (Wijesinghe, 2005). Further, author researched on rapidly mushrooming condominiums in Colombo and revealed that

water leakage occur higher degree in condominium and identified water stagnation, spalling, rain penetration, blocking channel and gutter, discoloration, water penetration, spill soffit, corrosion of reinforcement, growing of mosses, fungi and weeds, cracks, breaking drainage pipes as main defects in condominiums. Further, Hai (2007) described that have not satisfied as their expectations about physical and functional quality of existing condominiums in Vietnam. Moreover, author investigated in existing condominium and recognized the defects as cracks, corrosion, settlements, water leakages, spalling, stagnation, falling off protective covering, mosses, fungi and weeds occur in external wall, displacement and dislocation of structures in condominium in Vietnam.

Subsequently, most latent defects appear only in the occupancy phase and such defects are reported rarely by contractors as well as designers (Chong & Low, 2005). Moreover, author conducted a research regarding the occupancy stage defects on 74 numbers of buildings in Singapore context and discovered that cracks occurred most frequently and chip off, efflorescence, discolored tiles, hollowness, stains, unevenness, delaminated tiles and water seepage also occurred frequently at occupancy stage in most of the buildings. In addition to that, author highlighted that various elements develop various potential latent defects. According to his study, most of the latent defects were distributed on roof, plumbing and sanitary area, ceilings, doors, electrical and mechanical, external wall, windows, internal wall and floor elements as well as floor was identified as the most defective element at the occupancy stage.

Lee and Kim (2018) described that various defects occur during maintenance phase weaken building's performance. Moreover, author examined on 48 residential apartments in Korea and revealed that broken item was the most frequently occurred defect type and water problem, surface appearance, missing task, incorrect installation, corrosion detachment and affected functionality were the defect types occurred during occupancy phase. Further, author highlighted that latent defect risk is to be concentrated on finish work, reinforced concrete and MEP works rather than masonry, doors and windows, furniture and miscellaneous work types.

However, according to existing quality standards, structural defects can be rectified during construction stage as well as functional defects and aesthetic defects retain and appear after handed over. In general, latent defects are marks, small cracks, mess, stains, wall unevenness, floor unevenness, fitting and fixture in toilet, missing and incorrect grouting in tile (Forcada et al., 2013). Further, De Silva and Ranasinghe (2010) researched on occupancy stage defects in condominiums in Colombo Metropolitan region and author found 86.1% defects in services such as air condition, lift and fire, 84.94% defects in water proofing, 76.6% paint defects and joinery, window and door defects, ceiling component defects, masonry wall defects, structural concrete defects, chemical and biological attacks, duck work and plumbing defects as frequently occurred defects in condominiums.

Apart from this, there are some common types of defects including structural defects such as collapse and cracks, faulty drainage system, plumbing defects, defects in lighting and electrical wiring, insufficient suppression or fire protection system and insufficient sound proofing or insulation, vermin infestation or termite, fungus, mold, wood rot and dry rot (Ahzahar et al., 2011). Moreover, water damages, leaning walls, sagging floors, internal wall cracks and foundation cracks are some common building defects (Buys & Le Roux, 2013).

Table 2.2: Latent defects in various contexts

Latent defects	Context	Literature Sources
Water leakage, water stagnation, spalling, rain penetration, blocking channel and gutter, discoloration, water penetration, spill soffit, corrosion of reinforcement, growing of mosses, fungi and weeds, cracks, breaking drainage pipes	Condominiums in Colombo, Sri lanka	Wijesinghe (2005)
Cracks, corrosion, settlements, water leakages, spalling, stagnation, falling off protective covering, mosses, fungi and weeds occur in external wall, displacement and dislocation of structures	Condominiums in Vietnam	Hai (2007)
Cracks, chip off, efflorescence, discolored tiles, hollowness, stains, unevenness, delaminated tiles and water seepage	Buildings in Singapore	Chong and Low (2005)
Broken item, water problem, surface appearance, missing task, incorrect installation, corrosion detachment and affected functionality	Apartments in Korea	Lee and Kim (2018)
marks, small cracks, mess, stains, wall unevenness, floor unevenness, fitting and fixture in toilet, missing and incorrect grouting in tile	Buildings in Spain	Forcada et al (2013)
Defects in services such as fire, lift and air condition, water proofing defects, paint defects, joinery, window and door defects, ceiling component defects, masonry wall defects, structural concrete defects, chemical and biological attacks, duck work and plumbing defects	Condominiums in Colombo, Sri lanka	De Silva and Ranasinghe (2010)
structural defects such as cracks or collapse, faulty drainage system, plumbing defects, defects in lighting and electrical wiring, insufficient suppression or fire protection system and insufficient sound proofing or insulation, vermin infestation or termite, fungus, mold, wood rot and dry rot	Buildings in Malaysia	Ahzahar et al (2011)
water damages, leaning walls, sagging floors, internal wall cracks and foundation cracks	Buildings in South Africa	Buys and le Roux (2013)

According to above studies, typical latent defects have been identified by various authors from different countries and those latent defects can be occurred in Sri lankan condominiums. Ultimately, spalling and chipping, efflorescence, discolored tiles, hollowness, stains, unevenness, delaminated tiles, water seepage, cracks, corrosion of reinforcement, paint discoloration, peeling paint/blistering, damaged/corroded ironmongeries, non-alignment in doors and windows, defects in sanitary wares, pipe leaking, functioning defects in service equipment (Fire, Lift, Air condition), biological attacks (Fungus/Algae) can be recognised as latent defects in Sri Lankan condominiums.

- **Cracks**

Cracks are commonly found latent defect in condominiums. Mostly cracks are caused dead load (heavy weight), heavy live load (human traffic), hollowness on the floor, moisture from rain and wet areas and strong sunlight (Chong & Low, 2005). Moreover, nonstructural type cracks such as shrinkage cracks, minor cracks, joint cracks and surface cracks are found in buildings. Joint cracks usually occur in joints of various structural elements such as brick wall/beam and break wall/column due to insufficient bonding material and varying plaster thickness. Surface cracks usually occur on the floor screed and are caused due to inadequate healing process. Minor cracks (<3mm) usually occur in the openings such as doors and windows. These cracks can be rectified easily by using cracks gauges (Suffian, 2013).

- **Moisture Problem**

Moisture related defects such water proofing failures commonly occur in condominium projects (De Silva & Ranasinghe, 2010). Normally, moisture related problem causes various building defects such as stains, corrosion, discoloration, growing algae and peeling paints. These defects occur due to some environmental aspects such as temperature, wind, rain water and ground water (Hassanain, Al-Hammad, & Fatayer, 2013). Water leakage is another defect occurs on floor and wall (Chew, 2005). Moreover, author stated that poor water proofing leads to higher moisture problems. Some causes such as faults during design, unsuitable ventilation,

poor workmanship and poor environment conditions rise the moisture related problems (Ali, Kamaruzzaman, Sulaiman, & Peng, 2010).

- **Water Seepage**

Water seepage also frequently occurs in condominium. It occurs in concrete area due to capillary effect in concrete structure and it encourages the moisture migration. But it takes some time to insert water into concrete and permit water to emerge from the concrete elsewhere. Usually, the time taken would be longer than the period of defects liability. Wet areas such as toilet or bathroom within the building and rain are the main roots of water. Water seepage is caused by some sources such as failure to provide moisture barriers, poor workmanship and poor performance of materials such as water proofing membrane and concrete. Some other defects such as stains, cracks and delaminated tiles are caused by water seepage (Chong & Low, 2005).

- **Staining Problem**

Stain problem is commonly found latent defect in facades of condominiums. Some stain problems such as algae and fungus attack, water mark and existence of moss occur in most building facades. Normally, it is caused by poor maintenance, usage of poor quality materials and poor design. High quality external painting containing anti fungus agents can be used to minimize the staining attack. But it harms the good appearance of the building facades (Suffian, 2013).

- **Wall Finishes Problem**

Wall finishes problem also another defect occurs in condominium during occupancy stage. Plastering, tiling and painting are the most common wall finishes of a building. Wavy surface of plaster, plaster cracks, discoloration, peeling paint and efflorescent are main defects occurring in wall finishes. Wavy surface means that the wall's plaster surface becomes wavy due to poor workmanships. Efflorescence means that white bleeding observed on the surface of wall due to high moisture on the surface of wall and chemical reactions of the wall materials (Suffian, 2013).

2.5 Causes of Latent Defects in Condominiums

Defects in construction are obvious within some related aspects and it consists corrective measures, defect consequences, inaccurate actions and causes (Josephson & Hammarlund, 1999). More than 82% of defects occurred due to managerial errors and such errors have latent and hidden characteristics as well as those errors are not visible during the construction operations (Atkinson, 2003).

According to Ransom (1995) most of the defects arise over external factors on building materials including main components air or rain water, moisture, solar radiation, weather and gaseous and solid contaminants, salt or ground water, corrosion, particular fungi attacks and biological agencies. Moreover, Lee and Kim (2018) described that various causes such as user, materials, lack of protection, workmanship and design originated the defect in occupancy phase as well as there are relationship among defects and age.

Watt (1999) stated that the main sources of building defects are remedial works and poor maintenance or inappropriate use, mismanagement, pollution, human intervention, other natural hazards, geochemical, meteorological and biological. Moreover, Riley and Cotgrave (2011) illustrated that causes of defects can be divided as simple tear and wear, damages by external factors, poor workmanship, design errors and failure of materials. There are some contribution factors such as motivational and organizational factors, lack of knowledge, wrong assumptions, unawareness and insufficient information to defects during the design phase (Minato, 2003).

By the same token Rushton (2009) identified three basic causes, several sources with diverse examples as shown in Table 2.2;

Table 2.2: Causes of Defects

Causes	Sources	Examples
Dampness Caused by:	Rainwater	Defective gutters
	Surface Water	Penetrating dampness from high ground levels
	Service	Plumbing leaks
	Construction Water	Evaporation water from floor slabs, entrapped water in hollow cored planks
	condensation	Dampness in cold roof voids
Movements brought by:	Changes in temperature	Expansion or contraction of steel, brick work, etc.
	Moisture	Expansion or contraction in timber, brick work, etc.
	Applied loading	Furniture ,equipment, people, stock, etc.
	Accidents	Explosion, vehicle collision, etc.
	Ground movements	Subsidence
	Vibration	Traffic Vibration
	Chemical changes	Expansion due to sulphate attack, ASR
Chemical/biological change brought about by:	Dampness	Degeneration of materials such as gypsum plaster, chipboard, MDF in damp conditions
	Corrosion changes in temperature, electromagnetic, radiation	Corrosion of steel reinforcement
		Change of state-thermoplastic materials such as plastic, softening of asphalt
		Fading of paint, degeneration of mastic, clouding and distortion of polycarbonate
	Fungal attack	Sheeting
	Insect attack	Dry rot, wet rots
		Woodworm, house longhorn beetle, etc.

Source: (Rushton, 2009)

However, Josephson and Hammarlund (1999) researched in seven numbers of buildings via survey and observation and revealed that 45% of defects originated from site management, 32% of defects caused from design errors and 20% of defects originated from machine and poor materials. Further, Assaf, Al Khalil and Al Hamzi (1995) examined via interview and survey and exposed that defects are mainly generated by substandard equipment and materials, misspecification and design faults. Likewise, 35% of defects resulted from poor installation and operation, 58% through faults at design, 11% of defects from unexpected user requirements and 12% through poor systems and materials (Seely, 1987).

Accordingly, several origins to building defects have been highlighted by various authors from various countries and those following typical contribution factors can cause the latent defects in condominiums as well.

- **Failure of Construction Materials**

Construction materials such as brick, stone, timer and soil are used in building constructions. These construction materials are locally available. However, accurate analysis of defects and characteristics of the construction materials are significant in the material management of building (Ahzahar, et al., 2011). Further, author described that buildings are exposed all kind of diseases like old people. Therefore, engineers, contractors, architects and other involving people have to familiar with the usage of construction materials and proper understanding material management techniques to tackle the damages in the buildings.

- **Faulty Design**

Design error is commonly made and contractors usually try save the construction cost during the construction stage. Subsequently, this causes the defects over time. Design errors such as reduce the foundation, reduce the reinforcement bar size and decrease the column size are commonly done in constructions. This makes unsure situation about the loads and structures in future (Ahzahar et al., 2011). Design deficiencies and design errors are the main sources to latent defects and it should be improved at the design stage (Low & Chong, 2004).

- **Faulty Construction**

Faults during the construction mostly cause failure of the condominiums. Contractors use low grade concrete, poor quality materials and improper methods that are irrespective to the specifications as well as unawareness of consultant and client. Contractors have the sole responsibility for the faulty construction or poor workman ship (Ahzahar et al., 2011). Moreover, performance and quality of the building may weaken due to poor workmanship such as poor planning, poor material handling, poor material mixing and poor installation methods (Low & Chong, 2004).

- **Adverse Climatic Conditions**

Adverse climate conditions significantly affect the building materials and buildings. Especially, adverse tropical climate such as warm sunshine and heavy rainfall leads to weather related latent defects in buildings. Generally, outer building materials are directly exposed to external sources pollution, ultra-violet light, solar radiation, wind and rain. There are some latent defects such as defective plaster, mortar joint erosion, peeling paint, harmful growth and fungal stains arise due to adverse climate conditions (Ahzahar et al., 2011).

- **Polluted Environment and Dampness**

Condominiums those are located close to river or sea leads to have latent defects due to the water movement from ground to buildings. This causes instability of the structures as well as penetration of dampness. Moreover, polluted surroundings and sea water salt can significantly damages to the external façade of the buildings (Ahzahar et al., 2011).

- **Lack of Maintenance of Building**

Regular maintenance of condominiums reduces the defects during the occupancy phase. Ignorance of maintenance of condominiums may cause various defects from minor damage to severe structural failures. Abnormal deteriorations should be inspected and rectified as change tap washers, clean the spaces and voids, check lighting conductor, clean the gutters and harmful growths (De Silva, Sampath, & De

Silva, 2015). It is necessary to properly maintain the building and make sure the building performs effectively and efficiently to the occupants. Moreover, damages of building due to poor maintenance can lead to severe financial problems as well as legal issues for owners in future. Therefore, proper maintenance should be followed in order to enjoy the output of the buildings (Ahzahar et al., 2011).

- **Lack of Supervision of Work**

Proper site supervision increases the efficiency and performance of the building construction. Insufficient supervision leads to cause defects and damage over time as well as increase the cost of rectification/rework at the maintenance phase. Therefore, well-trained and experienced supervisors have to supervise the construction process to minimize the rework during the construction phase as well as occupancy phase (Ahzahar et al., 2011).

2.6 Effects of Latent Defects in Condominiums

Most of the occupants or owners of condominiums focus more concern on effects of the latent defects compared their causes. But successful rectification of such issues normally depends on the understanding of the sources and major sources instead of visible effects and symptoms (Riley & Cotgrave, 2011). Latent defects in condominiums buildings are serious issues (Isa, 2011). Further, author described that frequent latent defects may not have considerable effects where a very severe latent defect may occur once in occupancy stage. For instance, water may slightly leak through water supply fittings that are common issues and that may not affect much to the occupants. But contaminations in supply water from sewage may cause severe illness to the users. In general, the typical effects of latent defects in the condominiums can be considered as follows:

- **Loss of Functions**

Due to the defective work, smooth operation of the condominium building life will be affected (Isa, 2011). Latent defects may cause unnecessary expenditure for additional resources and delays in occupants' works (Ahzahar et al., 2011).

- **Loss in Performance of the System**

Losses in the performance of system occur when the performance of system significantly become slow or below the usual operation level. For instance, “disrupted or slow sewage pumping system chocked by solid waste discharge” (Chartered Institution of Building [CIOB], 2012). In addition to user need, the effect of mismatch between functional performance of the system and requirement of user are affected by shape and condition of condominiums. As the result the stability of system performance will be affected (Riley & Cotgrave, 2011).

- **Physic and Deterioration of the Building**

Durability of the external structures of condominiums may decrease due to latent defects that are directly connected with the weathering. Water/moisture and wind are main sources in this process. Further, the effect of aggressive compound and ultra violet radiation badly affect internal elements of condominiums. The loss of durability reflects itself in the degradation and wear of finishes (Riley & Cotgrave, 2011).

- **Effects on Human Health**

Latent defects affect the health of the maintenance professionals and occupants of the condominiums in long run. For instance, some sort of illness affects the occupants where they use legionella contaminated water in air conditioning system or central heating system (Chartered Institution of Building [CIOB], 2012).

- **Contractual, Legal and Other Industrial Related Issues**

Once the latent defects identified after purchased the condominium or rent it out for someone else. It will generate contractual issues and unwanted arguments among parties who involved in the transaction (Ahzaharet al., 2011).

- **Financial Loss**

Cost of latent defects is considered as resource consumption values for rectification of work as the result of latent defects. Equipment, labour, material and time are used to rectify latent defects. Normally, more time will take to identify the consequence of latent defects in condominium. Moreover, the rectification cost of latent defects is ranged as 5-10% of the construction cost (Josephson, 1998). Further, the financial loss of damage due to latent defects in the residential sector in Singapore has grown more than 30% in the past eleven years (Chartered Institution of Building [CIOB], 2012).

- Costs of remedying latent defects, including the cost of professionals' services (Low & Chong, 2004).
- Loss of rent because the building becomes unlettable due to inherent latent defects. Construction managers, tenants and owners wanted to reduce latent defects because dealing with latent defects was diminishing profits (Edirimane, 2006)
- Financial loss consequent upon the appearance of a latent defects (e.g., increased cost of working)
- Diminution in market value of a home, condominium or building by the presence of a latent defects (Ahzahar et al., 2011).

2.7 Rework/Rectification Cost of Latent Defects in Condominiums

When a defect arises, that should be repaired. This process called as rectification or rework. Rework means non-attainable of quality standard in the construction industry (Love, 2002). Further, rework is defined as useless attempt activity or process of re-doing that had implemented incorrectly in the first time (Love & Li, 2000). The rework/rectification cost significantly affects the construction organization as well as it adversely affects the productivity and performance of the organization (Mills, Love, & williams, 2009). Normally, latent defects are recognized or became visible at the occupancy stage or later it leads to rectification or rework. When identification

of latent defects gets delay, the cost for rectification/rework will increase (Love & Edwards, 2004).

The rectification/rework cost may vary in-between 0.4%-26% of total construction cost and the average cost is 12.4% (Burati, Farrington, & Ledbetter, 1992). Moreover, the cost of defects that occur at construction stage is 2-6% of the construction cost as well as the cost of defects that arise at maintenance stage or occupancy stage is 3-5% of construction cost (Josephson & Hammarlund, 1999). If the developer/contractor implement a proper quality assurance system during the construction operation, the cost of defects can be reduced to less than one percentage (<1%) of the contract value (Love & Li, 2000).

The rectification cost of defects decrease the profit of the contractor and the construction organization. Moreover, latent defects in building decrease the satisfaction of customers and damage the builder's reputation (Forcada et al., 2013). Further, profit margin and reputation of the organization may be significantly affected due to redoing cost of defects and loose the standards. It is necessary to improve the quality standards as well as reduce the cost of rectification work (Abdul-Rahman, 1995). More consideration is necessary for maintenance work and frequent repair work in condominiums (Sulochana, 2007).

2.8 Remedial Measures to Mitigate the Latent Defects in Condominiums

Repetition of latent defects can be avoided or prevented through correcting or eliminating the root causes (Josephson, 1998). More efforts have to be done at material quality control and design rather than just workmanship to limit the latent defects (Chong & Low, 2005). Normally, designers have ability to design against the environment that would help to eliminate many of latent defects (Chong & Low, 2006). Moreover, decision making processes on selecting quality construction materials minimize the potential of latent defects and life cycle cost during maintenance phase (Bortalini & Forcada, 2018).

Poor maintenance causes major defects during the occupancy. End users such as owners and tenant have great responsibility to maintain and sustain the

condominiums (De Silva & Ranasinghe, 2010). Strategies have to be established in short-terms to take immediate reactions to take corrections once the defects occurred and in long-term to take actions right from development stage to detect and eliminate the defects throughout the life cycle of the condominiums (De Silva, Sampath, & De Silva, 2015). Efficient quality control system has to use before handover in order to minimize the rework/rectification cost occurred during occupancy and maintain the reputation of developers (Lee & Kim, 2018).

Apart from this, some tests are used to detect the latent defects. For instance, the level of silt content in sand are measured by using grout that is very useful in predicting defects such as hollowness problems and pointing during the occupancy (Chong & Low, 2005). Moreover, some traditional techniques can be used to monitor the defects such as dovetail tags which are used to determine the temperature changes, fissure meter which is used to measure the movements of two points, strain gauges which is used to accurately assess the strains and accelerometer which is used to measure accelerations (Freitas, 2013).

2.9 Summary

This section carries the knowledge obtained from the previous literature on latent defects in condominiums. It has formed the theoretical background to this study. It was prepared to present the knowledge gap level and approximately decide how this current research works fit to develop the awareness required to assist to boot condominiums in Sri Lanka.

The pertinent literature review has presented that there is lack of previous researches for this current study on latent defects in condominiums. There is no record to show the level of latent defects or other important details that could offer the ways of understanding and meanings to effectively mitigate latent defects.

This chapter provides a comprehensive literature review on concept of condominium, significance of condominium, type of condominium, background of defect, causes, effects and remedial measures of latent defects.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

The previous chapter described the theoretical background of the area of study and this chapter explains research methodology adopted to achieve the established research aim and objectives. This chapter provides the overview of the total research process of this study. Accordingly, research design including research approach, data collection techniques and data analyzing techniques are explained in detail.

3.2 Research Process

The research process involves series of steps organized in a sequence that is necessary for the effective execution of a research (Kothari, 2004). The research process adopted in this study is illustrated in Figure 3.1.

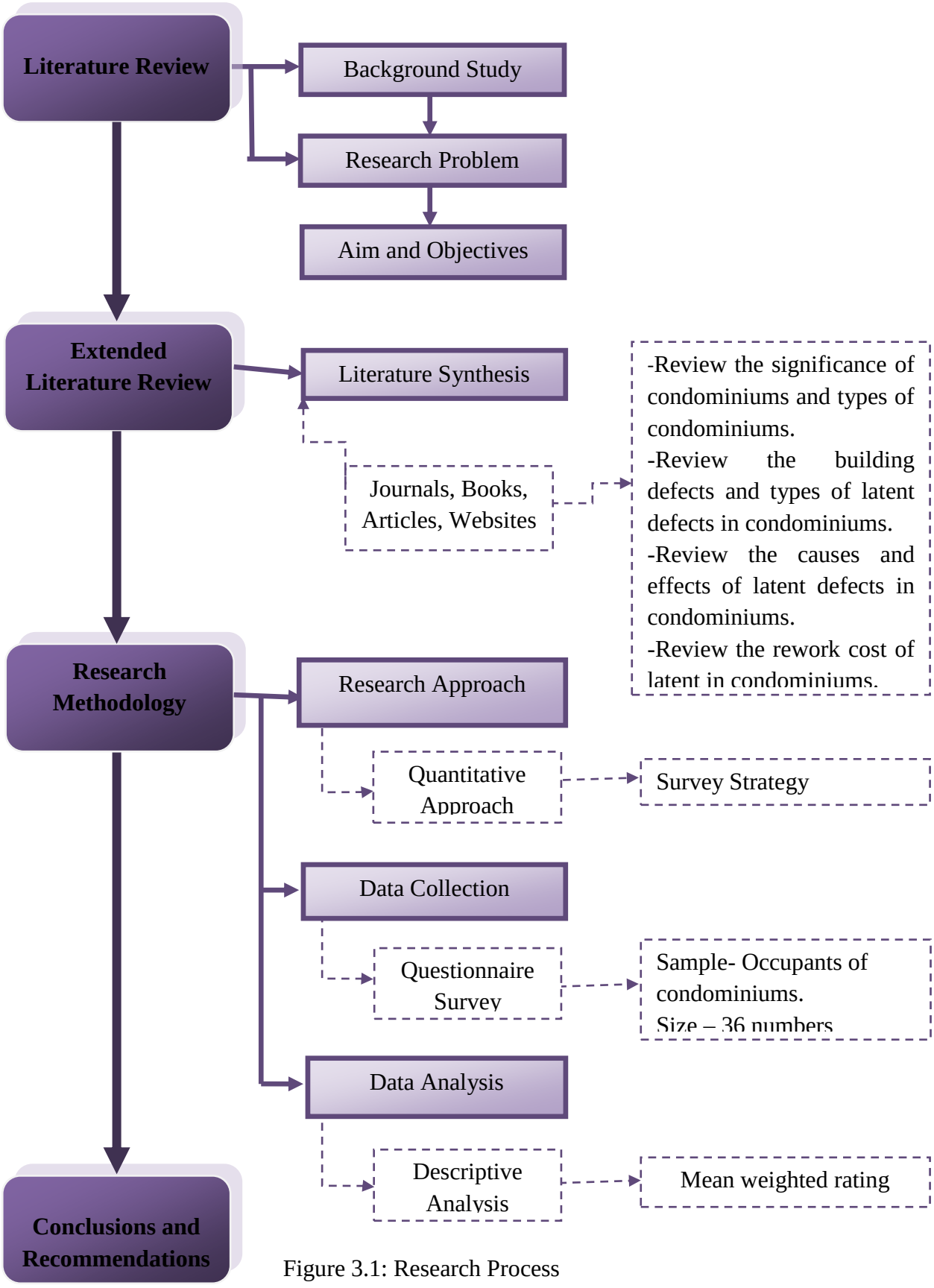


Figure 3.1: Research Process

3.3 Research Design

Research design is the systematic procedures to solve the research problem by linking data collection and analysis to results and thereby to conclusions (Fellows & Liu, 2008). It is important to develop proper research design since the end outcomes of the research vastly rely on the research design (Taylor, 2010).

The research design of this research study is developed throughout the following subsections.

3.3.1 Research Approach

The research approach can be generally divided into two categories namely the qualitative approach and quantity approach (Yin, 2009). Research strategies under the quantitative approach include survey and experiment when grounded theory, ethnography and case study belong to the qualitative research approach (Taylor, 2010).

Considering several aspects, 'Survey' which is under the quantitative research approach was decided as the most applicable research strategy for this study. The survey approach involves collecting data from a fraction of the population which is called 'Sample', analysing the collected data through statistical methods and generalising the findings to the population with quantitative descriptions (Kraemer, 2002).

Survey is generally used in commercial and academic sector to collect data from the sample of individuals. Sample means potion of population has been commonly studied by a structured tool in the questionnaire (Janes, 2001). Yin (2009) stated that research problem is the leading criterion for the research approach for a particular study. Further according to the author, *'Who', 'What', 'Where', 'How Many' and 'How Much'* type questions require the conduct of surveys which is under the quantitative research approach. This research is aimed to assess the impact of latent defects in condominiums in Sri Lanka. It denotes 'What' type of research problem.

This is the prime reason behind the selection of ‘survey’ as the research strategy for this research.

Quantitative approach tries to collect factual data and to learn relationship between facts and analysis of the data to yield quantified results (Fellows & Liu, 2008). This fits with the data analysis requirement of this research. In addition, survey approach is suitable ‘when control of the dependent and independent variables are impossible or not desirable’, ‘when the phenomena of interest arise in the recent past or current time and ‘when the phenomena of interest must be studied in their natural setting’. These characteristics are also consistent with the features of this research proving that the survey approach is the most applicable to this research (Kraemer, 2002). Being quantitative, survey approach produces valid and objective descriptions of the phenomena studied (Taylor, 2010).

Moreover, a similar methodology has been followed by Chong and Low (2005) to identify the defects at construction stage and occupancy stage in Singapore and Shirkavand (2015) to identify the most common building defects at post-handover stage in Norwegian construction projects. This also proves the suitability of the selected research approach and strategy for this study.

3.3.2 Research Technique – Data Collection

Various data collection methods such as simulation, participation, observation, document survey, questionnaires and interviews can be done in researches (Fellows & Liu, 2008). The questionnaire survey was used as the data collecting technique for this research with perception to quantitatively extract the general view of the occupants of condominiums related to the subject area.

3.3.2.1 Pilot Survey

After preparing the draft questionnaire based on the literature findings of previous research studies, a pilot survey was conducted with view to identify whether the questionnaire was comprehensive enough to collect required data from the occupants of condominiums and whether it was developed in a way to successfully address the

anticipated research objectives. Pilot questionnaire (Appendix A) consisted four sections which were intended to address the general information of respondent and condominium, impact of latent defects, causes of latent defects and remedial measures to mitigate the latent defects. This pilot questionnaire was commented by five occupants. They were occupants including members of condominium management committee and had technical and practical experience in satisfying the requirements considered for becoming a respondent to this research. Taking consideration of the comments of the occupants, the identified latent defects during the literature review was adjusted and combined some defects accordingly and the impact in terms frequency of occurrence, severity and rework/rectification cost of latent defects section was restructured to three separate pages. By restructuring so, it was expected that respondents' reluctance of answering on impact of latent defects would be minimized.

3.3.2.2 Questionnaire Survey

Questionnaire was developed with the assist of pilot survey and literature review. This questionnaire was designed to examine the cross-sectional behaviour pattern of individual respondents towards the latent defects in condominium.

Sample Selection

Selecting a sample from a population is called as sampling (Taylor, 2010). Generally, it is uneconomical and impractical to gather data from each individual people in the relevant population. Therefore, sample of the population is used (Bowling, 2002). The sample for this survey was selected randomly from the contact lists of occupants who have been living in condominiums and having practical experience and background knowledge in latent defects in condominiums.

These contacts were collected from the condominium management committee of condominiums which were registered under Condominium Management Authority (CMA) in metropolitan area.

Sample Size

The size of sample is significant in adequately replicating the behaviours of the population (Taylor, 2010). Moreover, author stated that sample size should be appropriately large, as a thumb rule, it must be at least thirty in orders to follow parametric statistics. According to Janes (2001), where the sample is large (i.e. more than 30), it is assumed that the sampling distribution tends to be normal and it should be enough to carry out the statistical analysis. Concerning all these factors and the time constraints, the sample size was decided as 36 for this research study.

Questionnaire Design

The questionnaire was structured into four sections namely 'Section A', 'Section B', 'Section C' and Section 'D' (Appendix B). Section A includes demographic characteristics of the respondents and condominiums in eight numbers of questions. Accordingly, the questions asked in this section includes the type of respondent (Q1), type of condominium (Q2), size of condominium (Q3), age of condominium (Q4) and other details related to condominiums (Q5-Q8).

Section B contains four numbers of questions to gather perspectives of occupants regarding the latent defects impact in terms of frequency of occurrence, severity and rework/rectification cost of latent defects and frequency of latent defects in elements of condominiums respectively. This section intends to fulfill the second objective of this research. In this section, the respondents are provided with a five-point likert scale in each question. The first question (Q9) in this section is ranged from 'Never occurred' to 'Very frequently occurred' as 1 for 'Never occurred', 2 for 'Slightly occurred', 3 for 'Moderately occurred', 4 for 'Frequently occurred' and 5 for 'Very frequently occurred' to indicate the frequency of occurrence of latent defects in condominiums. The next question (Q10) is given weightage as 1 for 'Not very severe', 2 for 'Not severe', 3 for 'Moderate severe', 4 for 'Severe" and 5 for 'Very severe to point out the severity concerning the technical impact and early attention of latent defects in condominiums. Third question (Q11) is weighted as 1 for 'Very low cost', 2 for 'Low cost', 3 for 'Moderate cost', 4 for 'High cost' and 5 for 'Very high

cost' to identify the rework cost significance latent defects in condominiums. The last question (Q12) of this section is scaled as 1 for 'Never occurred', 2 for 'Slightly occurred', 3 for 'Moderately occurred', 4 for 'Frequently occurred' and 5 for 'Very frequently occurred' to indicate the frequency of latent defects in elements of condominiums.

The aim of Section C is to identify the significant cause of latent defects in condominiums. This section relates to the third objective of this research, which was predominantly fulfilled through the literature review. This section comprises of a single question (Q13) comprising nine causes of latent defects identified from the literature review, for the respondents to identify the significant causes of latent defects in condominiums.

Last section D is to find the remedial measures that can be used to mitigate the latent defects in condominiums and to diminish the other issues related condominiums. This section intends to fulfill the fourth objective of this research. This section contains two questions. First question (Q14) requests the respondents to write down the remedial measures which have been followed in their condominiums or corrective actions that can be used in future to mitigate the latent defects in condominiums. Last question (Q15) requests the research participants to comment on other issues experienced in condominiums and remedial measures that would be used to sort out above commented issues in condominiums.

Conducting the Questionnaire Survey

The final questionnaires were delivered by hand after checking the accomplishment of respondents of the criteria to the research and the completed responses were collected personally.

3.3.3 Research Technique – Data Analysis

3.3.3.1 Descriptive Analysis

Descriptive statistics uses graphs, charts, percentages, tables and numerical descriptive measurements such as mean, median, mode, range etc. to indicate how a particular characteristic is distributed among a group of people (Taylor, 2010).

Section A (demographic characteristics) of the questionnaire was analysed using graphical analysis techniques such as pie charts, percentage subdivided bar diagrams and tables.

3.3.3.2 Mean Weighted Rating (MWR)

Mean Weighted Rating (MWR) technique is useful for this research. Because it is capable of giving a decision on significance of parameter with related to the received mean values. Moreover, the research has used a continuous scale from 1-5 making it possible to use the formula with the help of Excel.

Therefore, all questions of Section B of the questionnaire were analyzed by calculating the Mean Weighted Rating (Equation 3.1) of each factor in the question, in order to fulfill the objective two of the research. MWR technique was used as the analysis method for Q9 to assess the frequency of occurrence of latent defects in condominiums. This technique was used in Q10 to assess the severity of latent defects in condominiums. Mean values of latent defects is considered as severity index. The severity index of latent defects were rated into three regions such as high severity range (severity index score ≥ 4), medium severity range (severity impact score 3-4) and low severity range (severity index score <3) (Allotey, 2014). Moreover, NWR calculation was used in Q11 to assess the impact in terms of rework cost of latent defects in condominiums. Moreover, Q12 was analysed by calculating NWR to assess the frequency of latent defects in element of condominiums.

$$MWR = \frac{\sum (Vi \times Fi)}{n}$$

Equation 3.1: Mean Weighted Rating (MWR)

Where,

Vi - Rating of each Factor given by respondent

Fi - Frequency of Responses

n - Total number of responses

3.4 Summary

This chapter has justified and discussed the process of this research and adopted methodology for this research. Survey strategy under quantitative approach has been selected to attain the aim and objectives of this study. Latent defects that are identified from literature review are used in the detailed questionnaire. Mean Weighted Rating tool has been selected to analyze the collected data from questionnaire.

CHAPTER FOUR

4.0 RESEARCH FINDINGS AND ANALYS1S

4.1 Introduction

The previous chapter presented the research methodology adopted for this research and this chapter presents the data analysis as well as results of the detailed questionnaire survey according to the above-mentioned methodology. The aim of this chapter is to present the research findings.

This chapter gives an explanation of collected data from various respondents and contains the results, after analyzing the collected data from the questionnaire survey. Discussion has been carried out within each section of data analysis with the purpose of deriving a conclusion of this study.

4.2 Profile of Selected Condominiums and Survey Participants

Rate of Respondents

The questionnaires were distributed to occupants who have been occupying in condominiums. Some occupants were also members of condominium management committee such as condominium managers and maintenance professionals. Most of the occupants had practical experience and enough knowledge in latent defects in condominiums. The questionnaires were directly issued by hand.

The questionnaires were distributed among 40 occupants and 36 occupants responded properly. 90% rate of response was attained in the detailed questionnaire survey. Figure 4.1 illustrates the rate of responses from the selected sample;

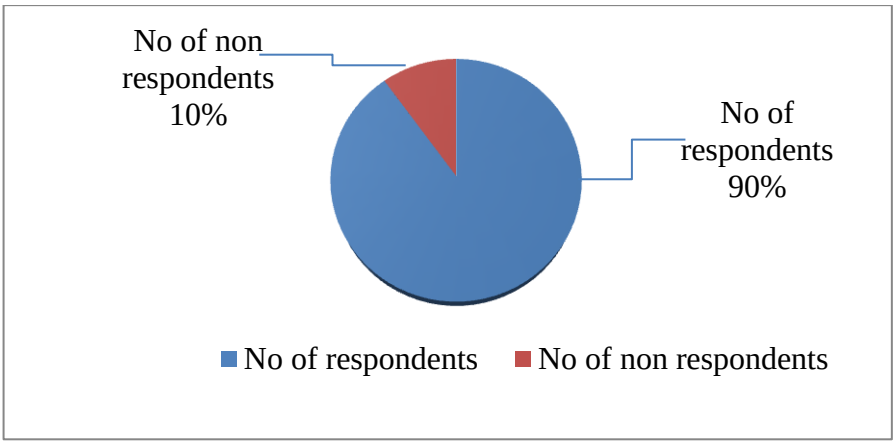


Figure 4.1: Rate of Response

Profile of Selected Condominiums

As first of the survey, the questionnaire collected the general information about condominiums such as type of condominiums and age of condominiums in number of years from functional operation commenced. The data was collected from 36 respondents from 16 various selected condominiums. All the condominiums were semi-luxury type condominiums.

The percentage distribution of the various ages of condominiums where the data collected is illustrated in Figure 4.2.

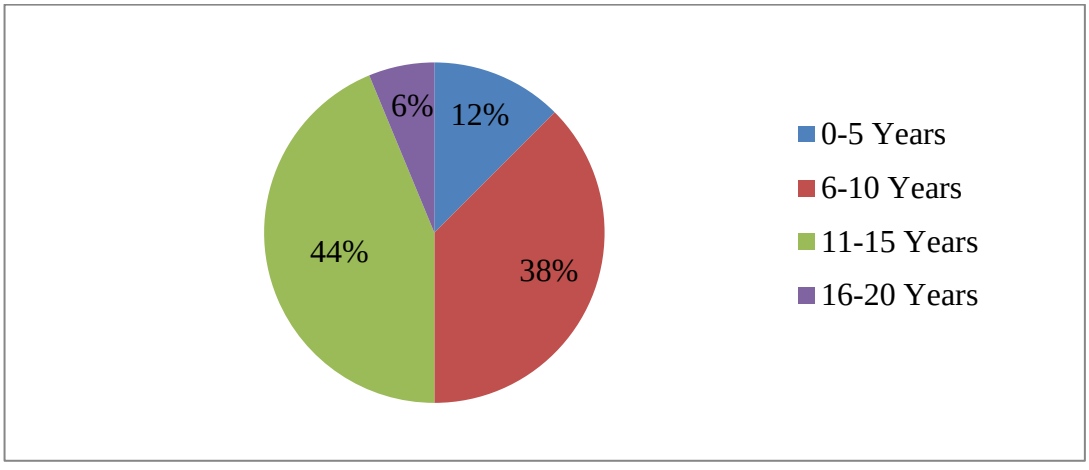


Figure 4.2: Percentage Distribution of Age of Condominiums

As illustrated in Figure 4.2, Age of condominiums was up to 5 years represented 12% (2 out of 16). Whilst, age of condominiums between 6-10 years was about 38% (6 out of 16), 11-15 years condominiums were represented by 44% (7 out of 16). Subsequently, age of condominiums between 16-20 years was about 6% (1 out of 16).

Profile of Participants

The questionnaire collected the general information about the participants' demographic details such as type of respondents, respondents from various sizes of condominiums in terms of number of floors and respondents from various age of condominiums in number of years.

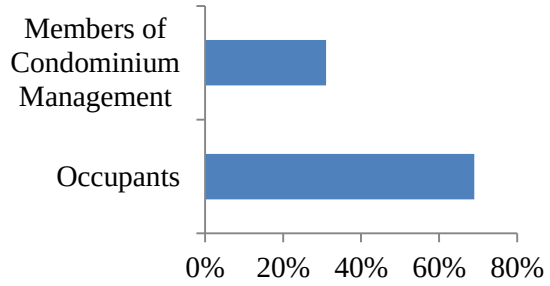
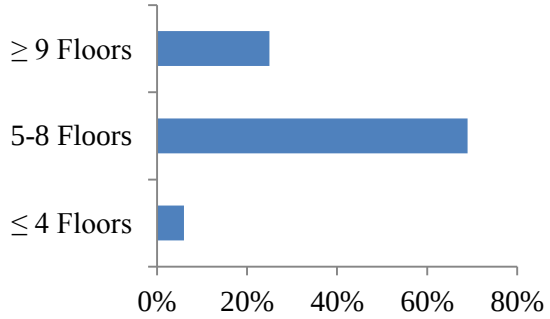
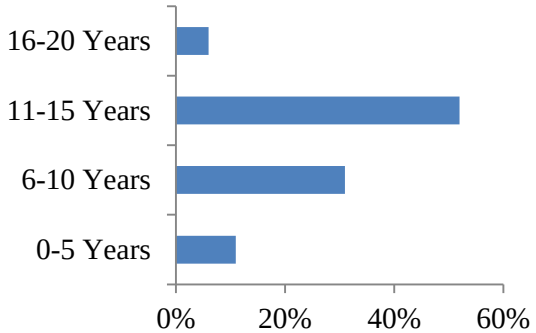
The respondents can be categorised as occupants and members of condominium management as indicated in Table 4.1. 69% (25 out of 36) of the respondents were main occupants of condominiums while balance 31% (11 out of 36) of the respondents were members of condominium management committee such as condominium managers and maintenance professionals.

The data was collected from different respondents from various sizes of condominiums and it was categorized according to number of floors as shown in the Table 4.1. Each condominium has various numbers of units per floor according to the gross floor area. As per the composition presented in Table 4.1, only 6% (2 out of 36) of the respondents were from up to 4 floors condominiums, 69% (25 out of 36) of respondents were from 5-8 floors condominiums and other 25% (9 out of 36) of respondents were from above 8 floors size condominiums.

The data was collected from different respondents from various ages of condominiums in years as indicated in Table 4.1. It has been grouped by using the scale of 0-5 years, 6-10 years, 11-15 years and 16-20 years. According to the composition shown in Table 4.1, 11% (4 out of 36) of respondents were from 0-5 years condominiums, 31% (11 out of 36) of respondents were from 6-10 years, other 52% (19 out of 36) of respondents were from 11-15 years and only 6% (2 out of 36) of the respondents were from 16-20 years age of condominium.

Table 4.1 provides a summary of the demographic information obtained from research participants.

Table 4.1: Demographic Profile of Participants

Demographic information		Number of Respondents	Percentage of Respondents
Type of Respondents	Occupants	25	
	Members of condominium Management Committee	11	
Size of Condominiums	≤ 4 Floors	2	
	5-8 Floors	25	
	≥ 9 Floors	9	
Age of Condominiums	0-5 Years	4	
	6-10 Years	11	
	11-15 Years	19	
	16-20 Years	2	

4.3 Impact of Latent Defects in Condominiums

This section questionnaire was developed to assess the impact of latent defects. This section discuss the frequency of occurrence of latent defects, the severity of latent defects, the rework/rectification cost of latent defects and frequency of occurrence of latent defects in elements of condominiums. The types of latent defects have been identified along with the options indicated by the occupants including members of condominium management committee and the pre-listed latent defects in the questionnaire. Total nineteen (19) latent defects have been identified in condominiums including the respondents indicated optional defects.

4.3.1 Frequency of Occurrence of Latent Defects

The respondents were requested to point out the frequency of occurrence of latent defects that were experienced after they occupied in the condominiums. For this purpose, five-point likert scales were introduced and ranged from 'Never Occurred' to 'Very Frequently Occurred'. The frequency of occurrence of latent defects has been identified by calculating the mean weighted rating (MWR) for each latent defect. The formula used for the calculation of mean weighted rating has been illustrated in section 3.3.3.2. The frequency of occurrence of latent defects is shown in Table 4.2;

Table 4.2: Frequency of Occurrence of Latent Defects

No	Latent Defects in Condominiums	Respondents	MWR	Rank
1	Water seepage	36	3.75	1
2	Crack	36	3.67	2
3	Defects in sanitary wares	36	3.47	3
4	Damaged/corroded ironmongeries	36	3.28	4
5	Paint discoloration	36	3.14	5
6	Functioning defect in service equipment (Fire, Lift, Air condition)	36	3.06	6
7	Pipe leaking	36	3.03	7
8	Peeling paint/blistering	36	2.97	8
9	Delaminated tiles	36	2.86	9
10	Stains	36	2.83	10
11	Spalling and Chip off	36	2.81	11
11	Biological attacks (Fungus/Algae)	36	2.81	11
13	Efflorescence	36	2.64	13
14	Non-alignment in doors and windows	36	2.53	14
15	Unevenness	36	2.50	15
16	Discolored tiles	36	2.28	16
17	Hollowness	36	1.83	17
18	Corrosion of reinforcement	36	1.81	18
19	Defects in pantry cupboard	36	0.92	19

Water seepage being the first in the ranking with the mean weighted rating value of 3.75, are recognised as the most frequently occurred and unavoidable latent defect in condominiums by the respondents. Water seepage is a transferable latent defect and it causes other latent defects over time. Generally, capillarity in concrete encouraged moisture migration in wet area like toilet in condominiums. Subsequently, cracks were identified as a second frequently occurring latent defects with the mean weighted rating 3.67. Cracks arise from minor crack in plaster to major cracks in concrete due to moisture from wet areas and rain, direct sunlight, dead load like heavy weight and live load like dense human movements in condominiums. Some cracks occur due to modifications done by house owners.

Moreover, according to calculated mean weighted rating, defects in sanitary ware (3.47), damaged/corroded ironmongeries in doors and windows (3.28), paint discoloration (3.14), functioning defects in service equipment such as fire, lift and air condition (3.06) and pipe leaking (3.03) also were identified as frequently occurred defects in the occupancy stage respectively. Because the calculated mean weighted rating values were more than moderate level (3) as mentioned in the scale. On the other hand, other defects from peeling paint/blistering (2.97) to defects in pantry cupboard (0.92) were considered as slightly occurred latent defects. Eventually, very few respondents responded the defects in pantry cupboard as slightly occurred latent defect in condominiums.

4.3.2 Frequency of Occurrence of Latent Defects in Elements

This section of survey was intended to find the frequency of latent defects in elements of condominiums. Each element has various potential to develop latent defects. For this purpose, five-point likert scales were presented and ranged from 'Never occurred' to 'very frequently occurred'. The frequency of occurrence of latent defects in elements has been identified by calculating the mean weighted rating for each element. The formula used for the calculation of mean weighted rating has been illustrated as in the section 3.3.3.2. The frequency of occurrence of latent defects in elements is shown in figure 4.3;

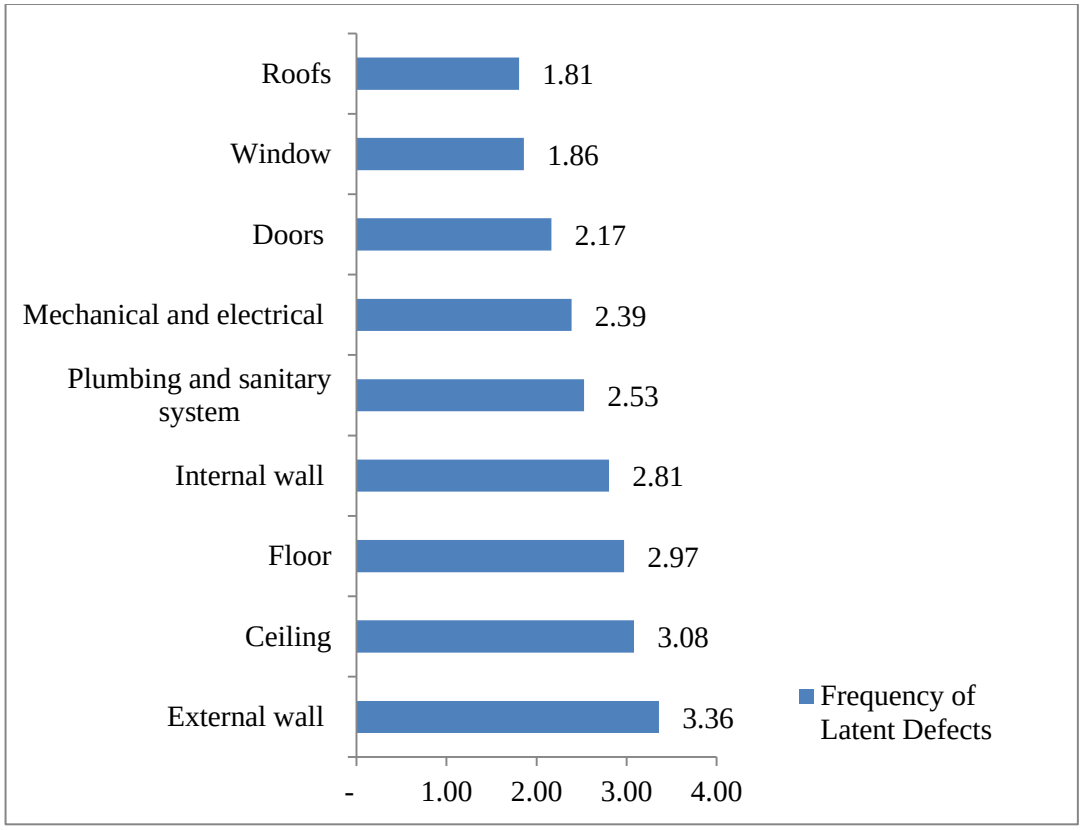


Figure 4.3: Frequency of Occurrence of Latent Defects in Elements

Figure 4.3 clearly shows that external wall within components of condominium has been developed the highest frequency of latent defects with the mean weighted rating 3.36 according to the observation given by respondents. The external wall get affect immediately from external causes such as moisture from rand and direct contact of sunlight. Cracks, moisture related defects and wall finishes related defects may occur frequently in the external wall. Ceiling was the second element to develop significant defects in occupancy stage with the mean value of 3.08. Subsequently, floor, internal wall and plumbing and sanitary system were frequently affected by latent defects in condominiums. Some latent defects occur in one element and transfer to other elements and cause other latent defects over time. For instance, water seepage which was identified as most frequently occurred latent defect. Moisture does transfer among elements like ceiling to wall, ceiling to floor, wall to ceiling, floor to wall where failure to provide moisture barrier.

4.3.3 Severity of Latent Defects

The respondents were requested to pint out the impact in terms of severity of latent defects that occurred in condominiums where they occupy. The severities of latent defects were recognised as the technical impact and the early attention required visible defects in condominiums. For this purpose, five-point likert scales were used with range from ‘not very severe’ to ‘very severe’. Accordingly, calculated mean weighted rating value of each latent defects was considered as severity index of latent defects in condominiums. The severity index is denoted as high severe latent defects carry higher weightage and less severe latent defects carry lower weightage. The severity index of latent defects is shown in the table 4.3;

Table 4.3: Severity Index of Latent Defects

No	Latent Defects in Condominiums	Respondents	Severity Index (MWR)	Rating
1	Crack	36	4.06	High
2	Stains	36	4.03	High
3	Water seepage	36	3.64	Medium
4	Delaminated tiles	36	3.44	Medium
5	Functioning defect in service equipment (Fire, Lift, Air condition)	36	3.28	Medium
6	Pipe leaking	36	3.14	Medium
7	Defects in sanitary wares	36	3.11	Medium
8	Peeling paint/blistering	36	3.08	Medium
9	Hollowness	36	3.06	Medium
10	Non-alignment in doors and windows	36	3.03	Medium
11	Efflorescence	36	2.97	Low
11	Biological attacks (Fungus/Algae)	36	2.89	Low
13	Corrosion of reinforcement	36	2.89	Low
14	Damaged/corroded ironmongeries	36	2.83	Low
15	Unevenness	36	2.78	Low
16	Spalling and Chip off	36	2.53	Low
17	Paint discoloration	36	2.47	Low
18	Discolored tiles	36	2.39	Low
19	Defects in pantry cupboard	36	0.89	Low

According to Table 4.3, Cracks were identified as most severe latent defects and stain was identified as second severe latent defect in condominiums by respondents. Mean weighted rating of crack was 4.06 while mean weighted rating of stain was 4.03. Further, the results of severity index of latent defects found condominiums were rated into three regions such as high severity, medium severity and low severity as described in section 3.3.3.2. Accordingly, cracks and stains have been captured as high severity latent defects. Because of the severity impact score is more than 4. Generally, high severity latent defects cause further damages to condominiums. For instance, cracks might lead to the major damages to other structure or other component or total failure of a system of structure over the time. Similarly, stains occur mainly by moisture from wet area or rain or chemicals usage and it become difficult to clean if left too long. Therefore, immediate repair is required for high severity latent defects in condominiums.

Subsequently, water seepage (3.64), delaminated tiles (3.44), functioning defect in service equipment (3.28), pipe leaking (3.14), defects in sanitary wares (3.11), peeling paint/blistering (3.08), hollowness (3.06) and non-alignment in doors and windows (3.03) were rated as medium severity latent defects. Moreover, the calculated mean weighted rating values were more than moderate level (3) as mentioned in the scale. On the other hand, others latent defects, from efflorescence (2.97) to defects in pantry cupboard (0.89) were known as low impact latent defects in condominiums in accordance with the perception provided by the respondents.

4.3.4 Rework/Rectification Cost of Latent Defects

The research participants were requested to point out the impact in terms of rework/rectification cost of latent defects during the occupancy stage in condominiums. The impact in terms of rectification/rework cost relevant to specific latent defect was indicated by using five-point likert scales with the range from ‘very low cost’ to ‘very high cost’. The impact of rework/rectification cost of latent defects has been identified by calculating the Mean Weighted Rating (MWR) values for each latent defect as described in the section 3.3.3.2. They have been extracted and presented as shown in the Table 4.4.

Table 4.4: Rework/Rectification Cost of Latent Defects

No	Latent Defects in Condominiums	Respondents	MWR	Rank
1	Crack	36	4.06	1
2	Paint discoloration	36	3.94	2
3	Water seepage	36	3.86	3
4	Unevenness	36	3.81	4
5	Delaminated tiles	36	3.67	5
6	Corrosion of reinforcement	36	3.42	6
7	Functioning defect in service equipment (Fire, Lift, Air condition)	36	3.31	7
8	Peeling paint/blistering	36	3.28	8
9	Pipe leaking	36	3.25	9
10	Discolored tiles	36	3.17	10
11	Stains	36	3.14	11
11	Spalling and Chip off	36	3.14	11
13	Efflorescence	36	2.97	13
14	Hollowness	36	2.89	14
15	Defects in sanitary wares	36	2.86	15
16	Non-alignment in doors and windows	36	2.83	16
17	Damaged/corroded ironmongeries	36	2.67	17
18	Biological attacks (Fungus/Algae)	36	2.58	18
19	Defects in pantry cupboard	36	1.11	19

According to the MWR values obtained in the above Table 4.4, cracks were recognised as the highest rework/rectification cost impact latent defect with a rating of 4.06 MWR in condominiums through the response given by respondents. In other words, cost of rework/rectification for cracks is higher than the cost of

rework/rectification of other latent defects. Because of cracks may cause significant condominium structural problems along with a reduction in the valuation of the condominiums. Paint discoloration was identified as a second rework/rectification cost impact latent defect with a mean value of 3.94. Because of simple repainting would not correct the problem for long. Discoloured paint surface should be properly cleaned before undercoat and overcoat are repainted. Hence, it is expensive to paint excessively.

Subsequently, water seepage (3.86), unevenness (3.81), delaminated tiles (3.67), corrosion of reinforcement (3.42), functioning defect in service equipment (3.31), peeling paint/blistering (3.28), pipe leaking (3.25), discolored tiles (3.17), stains (3.14) and spalling and chip off (3.14) were also identified as significant rework/rectification cost impact latent defects in condominiums. Because the calculated mean weighted rating values were more than moderate levels (3) as mentioned in the five-point scale. However, others latent defects, from efflorescence (2.97) to defects in pantry cupboard (1.11) were known as low rework/rectification cost impact latent defects in accordance with the perception provided by the respondents. Even though latent defects have significant rework/rectification cost impacts. Those should be immediately repaired. Otherwise it can lead to additional issues such as unrepairable and unsafe living in.

4.3.5 Comparison of Frequency and Severity of Latent Defects

It is necessary to evaluate the frequency of occurrence of latent defects and severity of latent defects to assess the true extent of the latent defects in condominiums concerning of both function and useability. Therefore, mean values of likert scale of severity of latent defects were graphed against the frequency of occurrence of latent defects and Figure 4.4 was derived.

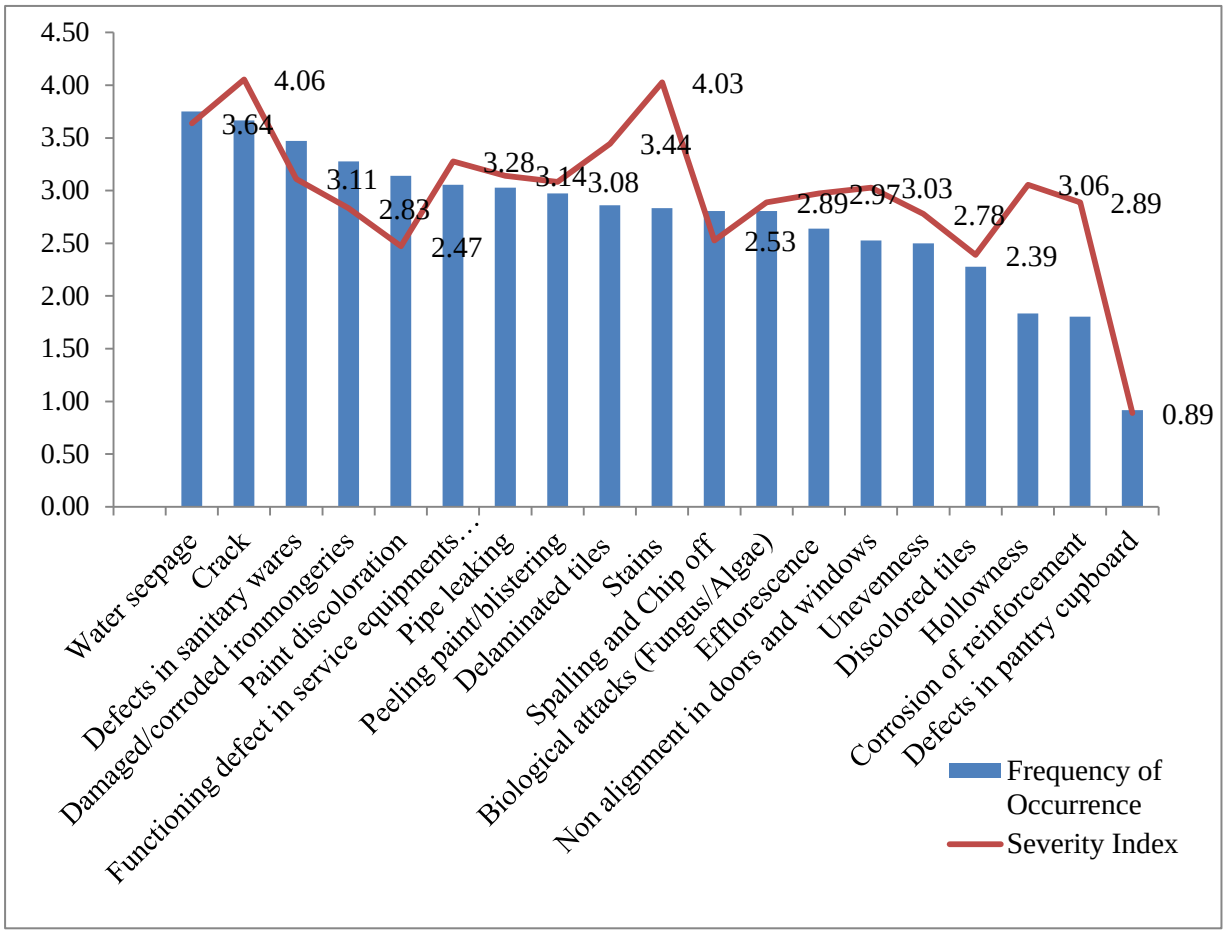


Figure 4.4: Comparison of Frequency and Severity of Latent Defects

According to figure 4.4, the impact in terms of frequency of occurrence of latent defects and severity of latent defects can be analysed. It has been noted that water seepage was the most frequently occurred (3.75) latent defect and degree of severity (3.64) was in the medium range. Cracks were the highest severity (4.06) latent defects and it was a second frequently occurring (3.67) latent defects. Moreover, even though damaged/corroded ironmongeries and paint discoloration significantly occurred in condominiums, degree of severity of these latent defects were in low range. On the other hand, even though stains being slightly occurred (2.83) defect among identified latent defects, it has ranked the higher range when considering the impact in terms of severity (4.03). By the same token, some latent defects such as hollowness, non-alignment of doors and windows, delaminated tiles and peeling paint/blistering have attained significant severity and slightly occurred. Eventually,

this graph depicts that the latent defects such as water seepage, cracks, defects in sanitary ware, functioning defects in service equipment and pipe leaking have a significant impact in terms of frequency of occurrence and severity in condominiums.

4.3.6 Comparison of Frequency and Rework Cost of Latent Defects

It is necessary to evaluate the frequency of occurrence of latent defects and the rework/rectification cost of latent defects to maintain the condominiums in good condition. Latent defects usually incur costs during investigation and rectification processes. Mean values of five-point scales of rework/rectification cost of latent defects were graphed against the frequency of occurrence of latent defects and Figure 4.5 was derived.

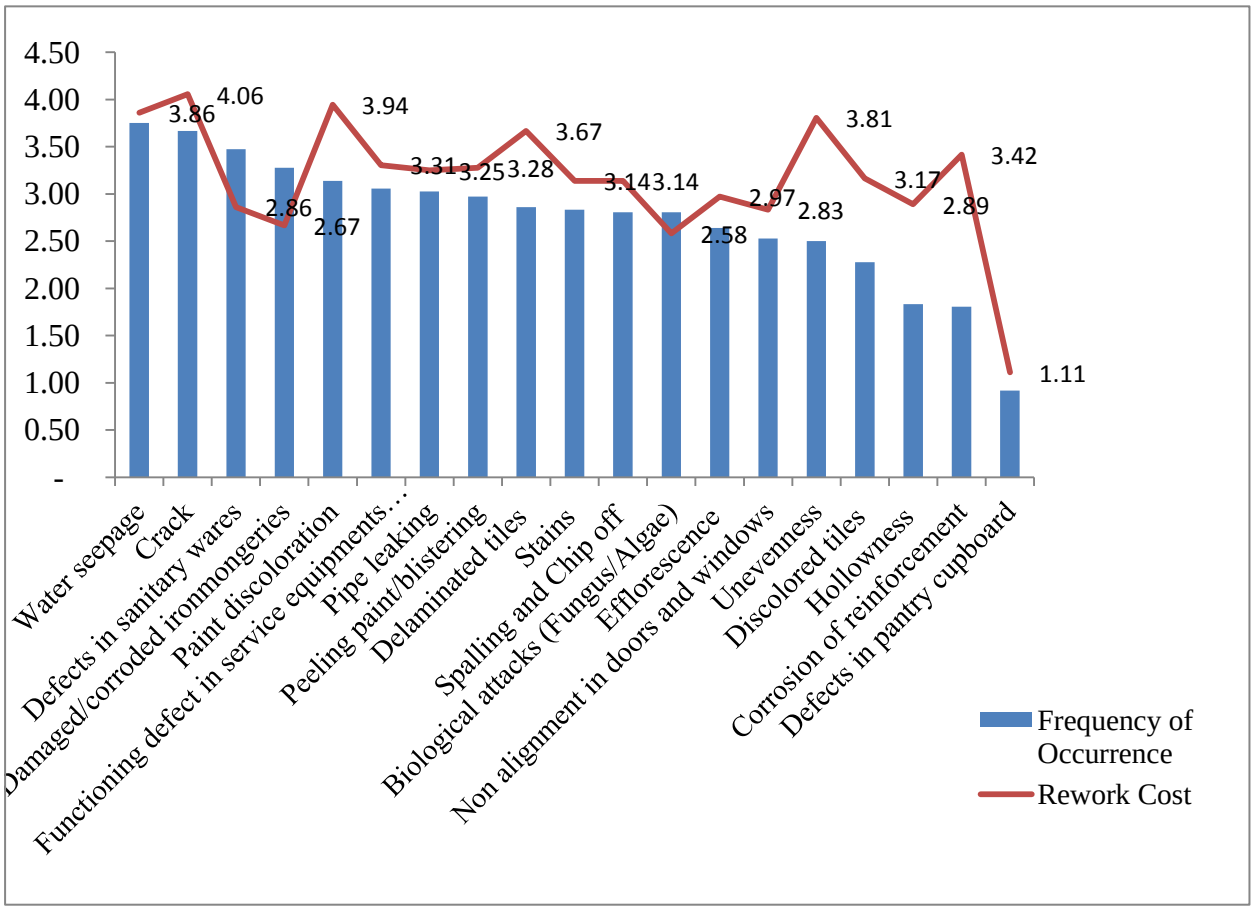


Figure 4.5: Comparison of Frequency and Rework Cost of Latent Defects

According to Figure 4.5, frequency of occurrence of latent defects and rework/rectification cost of latent defects can be analysed. It has been shown that water seepage was the most frequently occurred (3.75) latent defect and cost of rework/rectification (3.86) of water seepage was significantly impacting in condominiums. Cracks were the highest rework/rectification cost (4.06) required latent defect and it was a second frequently occurring (3.67) latent defects. Moreover, even though defects in sanitary wares (3.47) and damaged/corroded ironmongeries (3.28) significantly occurring latent defects, the cost of rework/rectification work of these latent defects was demanded low as the mean weighted values of 2.86 and 2.67 respectively. On the other hand, some latent defects such as corrosion of reinforcement, discolored tiles, unevenness, spalling and chip off, stains, delaminated tiles and peeling paint/blistering have attained significant impact on cost of rework/rectification and slightly occurred. Eventually, this graph depicts that latent defects such as water seepage, cracks, paint discoloration, functioning defect in service equipment and pipe leaking have a significant impact in terms of frequency of occurrence and cost of rework/rectification in condominiums.

4.3.7 Comparison of Severity and Rework Cost of Latent Defects

The impact in terms of severity concerning technical impact and early attention of latent defects and rework/rectification cost of latent defects should be evaluated to assess the effects of latent defects on maintenance of condominiums. Mean values of five-point scales of rework/rectification cost of latent defects were graphed against the mean values of severity of latent defects and Figure 4.6 was derived.

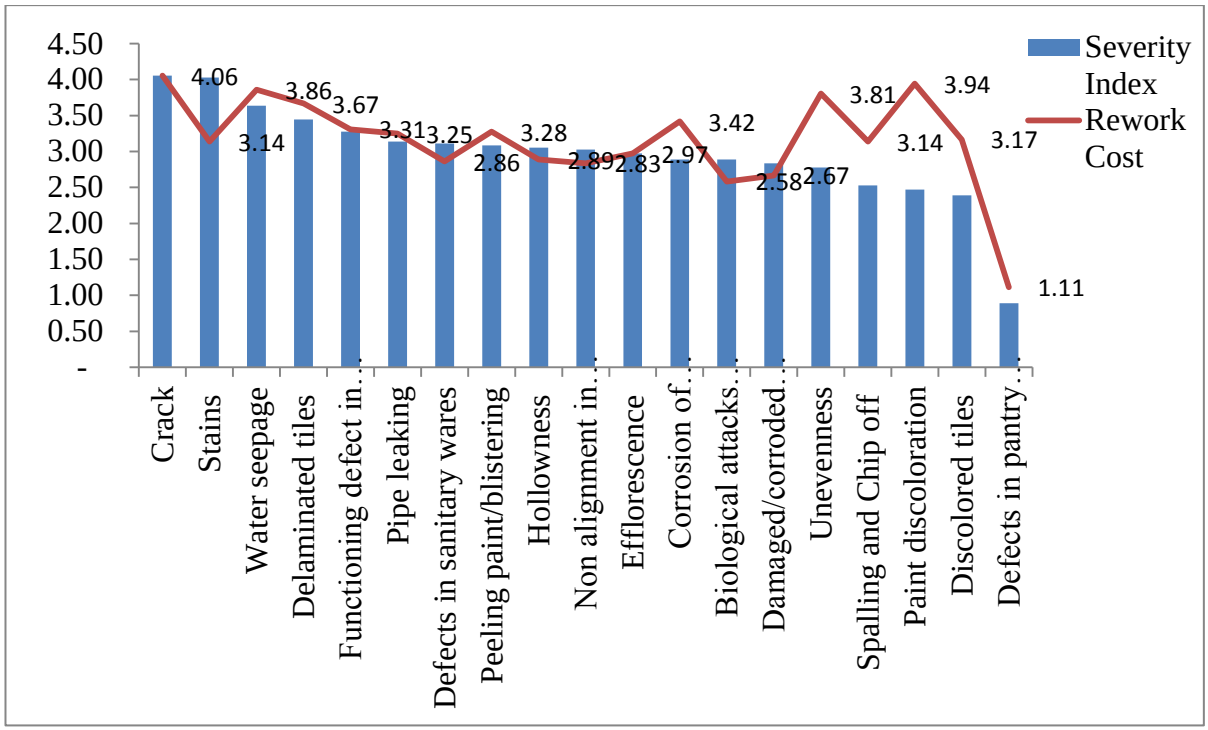


Figure 4.6: Comparison of Severity and Rework Cost of Latent Defects

According to Figure 4.6, impact in terms of severity of latent defects and rework/rectification cost of latent defects can be analysed. It has been revealed that cracks were the most severe latent defect with a mean value of 4.06 and the highest rework/rectification cost (4.06) required latent defect. Stain was identified as a higher severity latent defect with a severity index value of 4.03 and cost of rework/rectification of stain (3.14) significantly impacting condominiums. However, even though defects in sanitary wares, hollowness and non-alignment in doors and windows were recognized as significant degree of severity of latent defects, the cost of rework/rectification work of these latent defects was demanded low. On the other hand, some latent defects such as corrosion of reinforcement, unevenness, spalling and chip off, paint discoloration and discolored tiles were identified as significantly rework/rectification cost impact latent defects and these were identified as low severity latent defects in condominiums. Eventually, this graph depicts that latent defects such as cracks, stains, water seepage, delaminated tiles, functioning defects in service equipment such as lift, fire and air condition, pipe leaking and peeling

paint/blistering have a significant impact in terms of severity and cost of rework/rectification in condominiums.

4.3.8 Comparison of Frequency, Severity and Rework Cost of Latent Defects

The impact in terms of frequency of occurrence, severity and rework/rectification cost of latent defects should be evaluated to mitigate the effects of latent defects in condominiums. Calculated mean weighted values of each impact of each latent defect are shown in Table 4.5.

Table 4.5: Comparison of Frequency, Severity and Rework Cost of Latent Defects

No	Latent Defects in Condominiums	Frequency of Occurrence	Severity Index	Rework Cost
1	Water seepage	3.75	3.64	3.86
2	Crack	3.67	4.06	4.06
3	Defects in sanitary wares	3.47	3.11	2.86
4	Damaged/corroded ironmongeries	3.28	2.83	2.67
5	Paint discoloration	3.14	2.47	3.94
6	Functioning defect in service equipment	3.06	3.28	3.31
7	Pipe leaking	3.03	3.14	3.25
8	Peeling paint/blistering	2.97	3.08	3.28
9	Delaminated tiles	2.86	3.44	3.67
10	Stains	2.83	4.03	3.14
11	Spalling and Chip off	2.81	2.53	3.14
11	Biological attacks (Fungus/Algae)	2.81	2.89	2.58
13	Efflorescence	2.64	2.97	2.97
14	Non-alignment in doors and windows	2.53	3.03	2.83
15	Unevenness	2.50	2.78	3.81
16	Discolored tiles	2.28	2.39	3.17
17	Hollowness	1.83	3.06	2.89
18	Corrosion of reinforcement	1.81	2.89	3.42
19	Defects in pantry cupboard	0.92	0.89	1.11

The impacts in terms of frequency of occurrence, severity and cost of rework/rectification of latent defects are revealed in Table 4.5. It has been exposed that even though water seepage was identified as the most frequently occurred latent defects, cracks were the highest severity latent defect and the highest cost of rework/rectification required latent defect in condominiums. However, defects in sanitary wares frequently occurred and significantly more severity latent defect while peeling paint/ blistering, delaminated tiles and stains were significant severity and rework/rectification cost required latent defects. Because the mean weighted ratings of each impact of latent defect were above the moderate level (3) according to five-point likert scale values. Eventually, water seepage, cracks, functioning defects in service equipment and pipe leaking were recognised as having a significant impact in terms of frequency of occurrence, severity and rework/rectification cost of latent defects in condominiums. Above analysis clearly revealed the current impacts of latent defects in condominiums. Therefore, occupants, maintenance professionals, condominium management and construction professional have to recognize the significance of impact of latent defects in condominiums and have to focus more to find ways and means to lessen the defects in future.

4.3.9 Comparison of Frequency of Latent Defects and Age of Condominiums

The data was collected from various respondents from various ages of condominiums according to occupancy period in years. Table 4.6 indicates the impact in terms of frequency of occurrence with the age of condominiums. Accordingly, all types of latent defects slightly occurred in new condominiums which have the functional operation period less than five years. However, water seepage (3.73), damaged/corroded ironmongeries (3.55), cracks (3.45), paint discoloration (3.36), defects in sanitary wares (3.18), functioning defects in service equipment (3.09) and peeling paint/blistering (3.00) significantly occurred in 6-10 years functional operation period condominiums. Subsequently, majority of latent defects significantly occurred in 16-20 years occupancy period condominiums than 11-15 years age of condominiums. As a result, frequency of occurrence of latent defects is high in more occupancy period condominiums than new condominiums.

Table 4.6: Comparison of Frequency of Latent Defects and Age of Condominiums

No	Latent Defects in Condominiums	0-5 Years	6-10 Years	11-15 Years	16-20 Years
		MWR	MWR	MWR	MWR
1	Crack	1.50	3.45	4.21	4.00
2	Water seepage	1.75	3.73	4.21	3.50
3	Delaminated tiles	1.75	2.55	3.21	3.50
4	Unevenness	1.50	2.73	2.58	2.50
5	Stains	2.00	2.36	3.26	3.00
6	Hollowness	1.25	1.45	2.11	2.50
7	Discolored tiles	2.00	2.00	2.47	2.50
8	Efflorescence	1.75	2.64	2.84	2.50
9	Spalling and Chip off	1.50	2.45	3.21	3.50
10	Corrosion of reinforcement	1.00	1.55	1.89	4.00
11	Paint discoloration	1.50	3.36	3.42	2.50
12	Peeling paint/blistering	1.75	3.00	3.16	3.50
13	Damaged/corroded ironmongeries	2.50	3.55	3.26	3.50
14	Non alignment in doors and windows	1.50	2.73	2.53	3.50
15	Defects in sanitary wares	2.25	3.18	3.79	4.50
16	Pipe leaking	1.50	2.82	3.47	3.00
17	Functioning defect in service equipment (Fire, Lift, Air condition)	1.75	3.09	3.32	3.00
18	Biological attacks (Fungus/Algae)	1.50	2.55	3.21	3.00
19	Defects in pantry cupboard	-	0.82	1.05	2.00

4.3.10 Comparison of Severity of Latent Defects and Age of Condominiums

The data was collected from various respondents from various ages of condominiums according to occupancy period in years. Table 4.7 indicates the impact in terms of severity of latent defects and the age of condominiums.

Table 4.7: Comparison of Severity of Latent Defects and Age of Condominiums

No	Latent Defects in Condominiums	0-5 Years	6-10 Years	11-15 Years	16-20 Years
		MWR	MWR	MWR	MWR
1	Crack	3.25	4.45	3.95	4.50
2	Water seepage	2.50	3.82	3.68	4.50
3	Delaminated tiles	1.75	3.36	3.84	3.50
4	Unevenness	2.50	2.82	2.84	2.50
5	Stains	2.25	4.00	4.37	4.50
6	Hollowness	1.25	3.27	3.37	2.50
7	Discolored tiles	2.00	2.00	2.68	2.50
8	Efflorescence	1.50	3.18	3.26	2.00
9	Spalling and Chip off	2.00	2.55	2.63	2.50
10	Corrosion of reinforcement	3.00	2.45	3.05	3.50
11	Paint discoloration	1.75	2.82	2.53	1.50
12	Peeling paint/blistering	2.50	2.91	3.16	4.50
13	Damaged/corroded ironmongeries	2.50	2.73	2.95	3.00
14	Non alignment in doors and windows	2.75	2.55	3.42	2.50
15	Defects in sanitary wares	2.50	2.82	3.37	3.50
16	Pipe leaking	2.50	2.64	3.53	3.50
17	Functioning defect in service equipment (Fire, Lift, Air condition)	2.25	3.27	3.53	3.00
18	Biological attacks (Fungus/Algae)	2.00	3.09	2.89	3.50
19	Defects in pantry cupboard	-	1.00	1.00	1.00

Table 4.7 indicates the impact in terms of severity with the age of condominiums. Accordingly, cracks were a high severity latent defect in condominium whenever it occurred. All other latent have not severe when those occur within five years. However, majority of latent defects have high severity along with the age of condominiums.

4.4 Causes of Latent Defects in Condominiums

This section of questionnaire were tried to identify the root causes of latent defects in condominiums. Thus, the respondents were requested to mark the causes of latent defects from the listed causes which have been recognized in the literature review. Moreover, they were given the option to write down any other causes of latent defects in condominiums. Table 4.8 indicates the causes of latent defects in condominiums.

Table 4.8: Causes of Latent Defects in Condominiums

No	Causes of Latent Defects in Condominiums	No of Responses
1	Use of poor quality construction materials	36
2	Faulty construction	29
3	Faulty design / design error	26
4	Lack of maintenance of condominium	23
5	Lack of supervision of work	17
6	Polluted environment and dampness	14
7	Biological reasons	13
8	Common natural hazarders	2
9	Adverse climatic condition	1

According to table 4.8, use of poor quality construction materials was identified as the highest cause to latent defects in condominium by 36 respondents. Using quality construction materials are important in condominium construction. Because of it

would define the performance of the structure and resulted in any type of defects in the future or occupancy stage. The effect of using poor quality material may not take place in a year or two. But the effects would slowly begin to spread like a cancer in concrete in many years. Sometime construction materials are not used according to the specification by responsible parties and they purposely reduce the quality to save the cost.

29 respondents marked faulty construction as significant cause to latent defects. Faulty construction is known as poor workmanship. Usually, condominium occupants experience most of the defects problems during their occupancy due to poor workmanship. It is closely related to the developers or contractors of condominium construction. To mitigate this, proper quality assessment method should be used to evaluate and measure the quality of workmanship during the construction of condominiums.

Subsequently, faulty design/design error, lack of maintenance of condominiums, lack of supervision of work, polluted environment and dampness and biological reasons also were marked as significant causes to latent defects by majority of the respondents in condominiums.

4.5 Remedial Measures to Mitigate the Latent Defects in Condominiums

This section questionnaire was structured to find out the remedial measures and methods to mitigate the latent defects in condominiums. Perceptions of the respondents on existing management measures and future management practices were gathered to grip the data on above stated area. It will replicate the current situation and approach of occupants, maintenance professionals and condominium management towards managing and mitigating the latent defects in condominiums.

The respondents were asked to write down whether they are following any kind of practice or standard procedure to mitigate the occurred latent defects in their condominiums. Twenty seven occupants including members of condominiums management committee responded properly and nine occupants were not responded

properly in this part of question due to lack of knowledge in rectification of latent defects.

During the questionnaire survey, it has been recognised that all the condominiums where the data gathered have condominium management committee to manage the maintenance and defects occur in common areas on condominiums. Generally, condominium management committee members have enough knowledge to handle the defects by their experience or by using specialized maintenance professionals in relevant area. Moreover, the written remedial measures can be pointed out as follows;

- **Regular Maintenance in Condominiums**

Twenty seven occupants of condominiums noted that they have been following the regular maintenance auditing annually such as electrical auditing, fire extinguisher inspections, cleaning drainage lines and other services and painting the common area in particular intervals over time. Moreover, maintenance team arranges for timely repair and maintenance works to up keep the condominium in good condition. The rectification cost and maintenance cost are borne by house owners or tenants according to shares stated in the deed of mutual covenant or decisions taken in the meetings.

- **Occupants of Condominiums take Responsibility**

Twenty six occupants of condominiums stated that they have been sorted out the defects which arose in their own units by hiring relevant technician and borne the rectification cost. Actually, house owners have crucial responsibility to maintain not only their own unit or premises but also common parts of the condominiums. Such responsibility would not be released by just reporting the identified latent defects to condominium management committee. If any non-structural defects occur, owners should check the condition of the defect and carry out the repairs as necessary. Moreover, respective occupants ought to arrange themselves to appoint the professionals to coordinate the repair of latent defects which were found within their own units or premises as well as they should alert the condominium management

committee for arrange the maintenance professional to coordinate the necessary repair work in the common part in the condominiums.

- **Condominiums Management take Responsibility**

Twenty two occupants of condominiums pointed out that the condominium management has been rectified the latent defects which occurred beyond the house owners' control. Even though condominium unit owners responsible for repair the all the latent defects which occurred inside their condominium unit, some latent defects are created by conditions in a common area. Those defects should be rectified by condominium management committee to avoid the further issues. For instance, roof leak may cause damages to the interior of the top-floor condominium unit. Here, condominium management committee should take responsibility to fix the defects by using proper maintenance professional.

- **Investigate the Latent Defect and take Immediate Action**

Twenty one occupants mentioned that they have been taking immediate action once the defects discovered in the condominium unit or common area of condominiums. Whether the defects are severe or not, early attention should be taken as soon as possible. Otherwise, it leads to major damages to physical condition of the condominium or occupants or to other structures and it is difficult to rectify over time. For instance, stains occur mainly by moisture from wet area or rain or chemicals usage and it becomes difficult to clean if left too long. Once the latent defect discovered, the first step is to investigate the defect and document the degree of the defect. If the discovery of defect indicates larger issue, it is necessary to call a professional licensed contractor related to the subject to render an opinion on the problem. If the problem is serious like active water leak, the condominium unit owner or condominium management committee should correct immediately to mitigate any further damage.

- **Hire Licensed Professionals to Rectify Latent Defects**

Twenty two occupants of condominiums stated that they hire licensed maintenance professional to investigate and rectify the latent defects once those discovered in condominiums. Condominium management have contact list of experienced and licensed maintenance professionals for relevant area of wok in condominiums. For instance, once occupants find any water leaks in their premises, they have to inform to condominium management and call a plumber or licensed contractor to inspect and rectify the defects in relevant area to avoid the repeat defect or further damages in condominiums.

- **Supervise the Quality During the Construction**

Sixteen occupants of condominiums mentioned that some latent defects occur due to faults during the construction of condominiums. Mostly, condominiums are designed and constructed by the same developer/ contractor. Therefore, it is difficult to supervise and find the fault during the construction of condominiums. Some developers focus on developing multiple condominiums and try to cut the cost by using poor quality materials and poor workmanship. It develops defects after occupant occupied into the condominiums. Therefore, condominium unit owners have to assign a technical person to supervise the quality of materials and quality of workmanship to mitigate the problems during the construction and occupancy stage.

4.6 Remedial Measures to Manage the Other Issues in Condominiums

This section questionnaire was structured to recognize other issues which were experienced in condominiums and relevant remedial practices to mitigate the identified issues in future. Perceptions of the occupants on the management practices were gathered to grip the data on stated issues. It will replicate the current situation and approach of occupants and condominium management towards managing and mitigating the other issues in condominiums in Sri Lanka.

The respondents were asked to write down the other issues which they experienced in condominiums and some remedial measures to mitigate them. All the occupants and members of condominiums management committee responded properly. During

the questionnaire survey, it has been recognised that all the condominium where the respondents residing follow condominium management regulations and quality standards. However, occupants have been experiencing some common issues in the condominiums which can be pointed out as follows;

- **Vehicle parking issue**

Most of the condominiums have been allocated parking slots for each number of units in ground floor or basement floor. However, twelve occupants have issues in parking areas of condominiums. Because of they have not enough space to park vehicles for each unit. One reason, condominiums did not construct according to the given approval. Another reason, one particular condominium ground floor (Vehicle Park) has been merged with another condominium which was constructed some years early. As a result, they adjust with other unit occupants rotationally and park their vehicle in out of condominiums. It should be rectified by developers before construct the condominiums as well as condominium management has to arrange separate place to park the vehicles for each unit occupants.

- **Waste disposal issue**

All the occupants of condominiums have been following municipal council waste disposal standards. Accordingly, occupants have to dispose their waste daily into disposal bins which are arranged for different types of disposal in different colours separately. Usually, municipal council is responsible to collect and dispose the collected disposals. However, some condominium management has instructed to their occupants to keep their waste in the unit and dispose it once a week due to limited access of municipal council disposal vehicle. Because of this, occupants feel uncomfortable and unhealthy. Condominium management can sort out this waste disposal issue by hiring private cleaning service company to dispose the waste daily.

4.7 Summary

This chapter presents this research findings and analysis of the research findings under various sections address the objectives. Altogether total nineteen various types

of latent defects were identified in condominiums. Subsequently, impacts in terms frequency of occurrence, severity and rework/rectification cost of latent defects were identified separately. It was found that water seepage was recognised as the most frequently occurred latent defects, cracks and stain were identified as high severe latent defects and cracks were known as most cost significant latent defects in condominiums. External wall was identified as the most frequent latent defects developing element in condominiums. Causes of latent defects were analysed. Finally, remedial measures to mitigate the latent defects and other issues experienced in condominiums were pointed out and described.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This study presents a gap around latent defects and their impacts in terms of frequency of occurrence, severity and rework/rectification cost, as well as causes of latent defects in condominiums. This research adds new data to existing literature regarding the remedial measures and procedures which have been adhered by occupants and condominium management to mitigate the latent defects and other issues in condominiums. This chapter aims to present conclusions and recommendations of this complete research. Accordingly, this chapter starts with over view of this research and conclusions address the fulfillment of the objectives. Then this chapter discusses the recommendations of this research. Eventually, limitations and further research that can probably stem from this research are explained.

5.2 Overview of the Research and Conclusions

Review the past literature study, it has become obvious that latent defects have been significantly impact on condominiums with regards quality, time and cost if those not correctly mitigated. With this into consideration, this research aimed to assess the impact of latent defects in condominiums in Sri Lanka. Four objectives have been established to achieve the aim of this research as stated in the chapter one.

Initially, literature review was conducted to establish the research background. Then, with respect to the pilot questionnaire survey, a detailed questionnaire survey was carried out to ascertain the views of the occupants residing in condominiums including members of condominium management. Data analysis was done by using mean weighted rating technique and non-arithmetic answers were subscribed to achieve a general view of the research participants. The analysis was undertaken with a view to achieve the set-out objectives fruitfully.

The first objective of the study was to review the types of latent defects of latent defects pertaining to condominiums. It was attained from comprehensive literature review and then the findings of the literature were confirmed by questionnaire survey. Options were given to the research participants to point out any defects type that they experienced defects liability period. Accordingly, nineteen latent defects such as efflorescence, discolored tiles, hollowness, stains, unevenness, delaminated tiles, water seepage, cracks, spalling and chipping, corrosion of reinforcement, paint discoloration, peeling paint/blistering, damaged/corroded ironmongeries, non-alignment in doors and windows, defects in sanitary wares, pipe leaking, functioning defect in service equipment (Fire, Lift, Air condition), biological attacks (Fungus/Algae), defects in pantry cupboard were identified in condominiums.

The second objective of the study was to assess the impacts of latent defects in terms of frequency of occurrence, severity and rework cost in condominiums. Fulfillment of second objective was achieved from detailed questionnaire survey. Five point Likert scale was used to rate the impact of the latent defects. Mean weighted rating values of each type of latent defects were calculated with use of micro soft excel and analysed according to the described five-point scale in section 3.3.3.2. The frequency of occurrence of latent defects was examined and those frequencies were compared with each type of latent defects in Chapter four. Analysis of data exposed that water seepage was the most frequently occurred latent defect. Subsequently, frequency of occurrence in element was analysed and those frequencies were compared among each element. It revealed that external wall within the components of condominium has been developed the highest frequency of latent defects. Then, severity concerning technical impact and the early attention required visible defects were analysed by mean values and calculated severity index was compared with each other latent defects in Chapter four. It exposed that cracks and stains were the high severity latent defects. Another impact in terms of rework/rectification cost was analysed and compared. It showed that cracks were the most rework cost significant latent defects. Eventually, water seepage, cracks, functioning defects in service equipment and pipe leaking were recognised as a significant impact in terms of frequency of occurrence, severity and rework/rectification cost of latent defects in condominiums. Moreover,

frequency of occurrence and severity of latent defects are high in more occupancy period condominiums than new condominiums.

The third objective of the study was to recognize the causes of latent defects in condominiums. Identification of causes to latent defects was emphasized from literature survey and a section was comprised in the questionnaire to identify the causes of latent defects in condominiums. Several causes recognized from the literature review was listed out to avoid the reluctance of the research participants and to make them easy to understand. Research participants were given option to point out the causes experienced in occupying condominiums. Accordingly, use of poor quality construction materials was identified as the most significant cause to latent defects. Subsequently, faults during the construction, faults during the design and lack of maintenance in condominiums were also identified as major human causes where the attention should be placed upon in mitigating latent defects in condominiums.

The final objective of the study was to explore the measures to be taken to mitigate latent defects and other issues in condominiums in Sri Lanka. It was conducted by using semi-structured questions in the last section of the questionnaire. Respondents noted some remedial measures such as adhere regular maintenance in condominiums, occupants and condominium management take responsibilities to mitigate the latent defects, investigate and take immediate action by using licensed maintenance professionals once the latent defects discovered and follow quality assessment during the construction by assigning supervisors to mitigate the latent defects. Subsequently, condominium management has to take action to mitigate the vehicle parking issues and waste disposal issues in condominiums.

Moreover, findings implied that regardless the nature of the latent defect, it has a considerable direct cost impact over the individual who owns condominium units in one hand. On the other hand, the findings identifies there is a considerable opportunity cost involved for the owner as can spend the money to achieve other ambitions instead of spending money for defect repairs that can’t be recoverable. Therefore, it is needless to say that there is huge economic impact on the owners.

However, the findings identifies it is likely that the investment towards new condominiums will diminish when the developers develop new condominiums and do not provide reliable assurances relating to the latent defects for the people who are willing to own condominium units. Therefore, it is clear that the latent defect has a significant economic impact over both the owner and the developer.

5.3 Recommendations

The following recommendations can be made for mitigating the defects which occur after defects liability period in condominiums in Sri Lanka. The recommendations intend to assist to take precautions to mitigate the latent defects and their impact on condominiums in terms of quality, cost and time.

- The result of frequency of latent defects, severity level of latent defects and rework/rectification cost impact of latent defects in condominiums can be occupied in determining value of condominiums in Sri Lanka.
- Major causes to latent defects should be more focused during the construction and occupancy stage for similar projects also.
- Best remedial measures described in sub section 4.5 can be used to effectively mitigate the latent defects in condominiums.
- Regulations can be developed to minimize the cost impact over the owners.

5.4 Limitations

The major limitation for this study was the limitation of scope to condominiums. Regarding the defects was limited to latent defects due to complication of nature and comprehensiveness of scope. Moreover, this study was limited to Colombo metropolitan area due to time constrains of data collection.

5.5 Further Research

Further study areas can be found as follows:

- A similar research can carry out for civil engineering projects.
- A similar research can carry out in patent defects in condominiums.
- This study can be extended to define responsible persons for latent defects and legal related remedial measures for latent defects disputes.

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APPENDIX A

PILOT QUESTIONNAIRE

Dear Sir / Madam,

Regarding Dissertation -M.Sc. in Project Management

I am a postgraduate student of the Department of Building Economics at University of Moratuwa following M.Sc. in Project Management degree programme and I am conducting a research under the topic on "**Assessment of Impact of Latent Defects in Condominiums in Sri Lanka**".

I would be grateful if you could complete this questionnaire within your busy work schedule. The information gathered through this survey will be only used for this particular research. They will not be used for any other purpose and results would be summarized, and no specific referees will be made to individuals or firms. The information provided will be treated with strict confidence.

Thank you

Yours faithfully,

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ASSESSMENT OF IMPACT OF LATENT DEFECTS IN CONDOMINIUMS IN SRI LANKA

1. GENERAL INFORMATION

Q1. Type of Respondent

- ☐ Occupant (Owner)
- ☐ Member of Condominium Management

Q2. Type of Condominium

- ☐ Super Luxury Condominium
- ☐ Luxury Condominium
- ☐ Semi Luxury Condominium

Q3. Size of the Condominium

a. No of floors:…….

b. No of units in a floor:……..…...……...

Q4. Age of the Condominium

- ☐ 0-5 Years
- ☐ 6-10 Years
- ☐ 11-15 Years
- ☐ 16-20 Years

Q5. Effective period of usage of Condominium

a. Year of Completion:……..……..…

b. Year of commencing of functional operation:…….……..…..…

Q6. Maintenance of Condominium

- ☐ In house Committee
- ☐ Outsource to Maintenance Company

Q7. Registered with Condominium Management Authority (CMA)

a. Year of Registration:……..……..…

b. Does it presently Maintain by CMA:..…..…….……..…

Q8. Location of the Condominium:……

NOTE: This research is focused on the defects which are occurred after the Defect Liability Period (Latent defects are occurred after building occupied)

2. IMPACT OF LATENT DEFECTS IN CONDOMINIUMS

Q9. Have you noticed following latent defects in condominiums during the occupancy stage? If 'Yes' please tick ☑ into the first column check box according to the following scale.

1 – Never Occurred 2 – Slightly Occurre 3 – Moderately Occurred

4 – Frequently Occurred 5 - Very Frequently Occurred

Q10. Please tick ☑ the severity (technical impact and early attention) of following latent defects into the second column check boxes of the table according to following scale

1 – Not Severe 2 - Sever 3 - Moderate Severe

4 - Severe 5 - Very severe

Q11. Please tick ☑ the cost for rework/rectification of following latent defects into the third column check boxes of the table according to the following scale.

1 – Very Low Cost 2 – Low Cost 3 – Moderate Cost

4 - High cost 5 - Very High Cost

No	Latent Defects	Frequency of occurrence					Severity of latent defects					Rework/Rectification cost of latent defects				
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
1	Cracks	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
2	Water seepage	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
3	Delaminated tiles	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
4	Unevenness	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
5	Stains	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
6	Hollowness	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
7	Discolored tiles	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
8	Efflorescence	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
9	Chip off	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
10	Concrete spalling	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
11	Corrosion of reinforcement	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
12	Paint discoloration	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
13	Peeling paint/blistering	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
14	Damaged/corroded ironmongeries	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
15	Non-alignment in doors and windows	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
16	Defects in sanitary wares	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
17	Pipe leaking	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
18	Defects in fire system	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
19	Defects in lift system	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
20	Defect in sir conditioning system	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
21	Biological attacks (Fungus/Algae)	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
22	Other if any, please specify	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5

Q12. If you identified latent defects in the following elements, please tick ☑ the element with relevant number according to the following scale.

1 –Never Occurred 2 – Slightly Occurred 3 – Moderately Occurred

4 – Frequently Occurred 5 - Very Frequently Occurred

Elements	**Frequency of Occurrence of Latent Defects in Elements**					**Remarks**
	1	**2**	**3**	**4**	**5**	
Floor	1	2	3	4	5	
Internal wall	1	2	3	4	5	
External wall	1	2	3	4	5	
Doors	1	2	3	4	5	
Window	1	2	3	4	5	
Ceiling	1	2	3	4	5	
Roofs	1	2	3	4	5	
Mechanical and electrical	1	2	3	4	5	
Plumbing and sanitary system	1	2	3	4	5	
Other if any, please specify.	1	2	3	4	5	

3. CAUSES OF LATENT DEFECTS IN CONDOMINIUMS IN SRI LANKA

Q13. Please tick ☑ the following causes of defects which you think that can cause the above mentioned latent defects in condominiums

No	Causes of Latent Defects in Condominium	Mark	Remarks
1	Use of poor quality construction materials		
2	Faults in design / design error		
3	Faults during construction		
4	Adverse climatic condition		
5	Polluted environment and dampness		
6	Lack of maintenance of condominium		
7	Lack of supervision of work		
8	Common natural hazarders		
9	Biological reasons		
10	Other if any, please specify..		

4. REMEDIAL MEASURES TO MITIGATE THE LATENT DEFECTS AND OTHER ISSUES IN CONDOMINIUMS

Q14. What are the remedial measures can be done to effectively mitigate the identified latent defects in condominiums?

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Q15. Please comment on other issues experienced in your condominiums and remedial measures

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… Thank You …

APPENDIX B

QUESTIONNAIRE

Dear Sir / Madam,

Regarding Dissertation - M.Sc. in Project Management

I am a postgraduate student of the Department of Building Economics at University of Moratuwa following M.Sc in Project Management degree programme and I am conducting a research under the topic on "**Assessment of Impact of Latent Defects in Condominiums in Sri Lanka**".

I would be grateful if you could complete this questionnaire within your busy work schedule. The information gathered through this survey will be only used for this particular research. They will not be used for any other purpose and results would be summarized, and no specific referees will be made to individuals or firms. The information provided will be treated with strict confidence.

Thank you

Yours faithfully,

Akalya S.

Postgraduate student

Department of Building Economics

Faculty of Architecture

University of Moratuwa

Telephone: 077 6544626

E- mail: akalyas@yahoo.com

Dissertation Supervisor

Dr. Thanuja Ramachandra.

Senior Lecturer

Department of Building Economics

Faculty of Architecture

University of Moratuwa

Telephone: 071 440 7468

E- mail: thanuja03@hotmail.com

ASSESSMENT OF IMPACT OF LATENT DEFECTS IN CONDOMINIUMS IN SRI LANKA

SECTION A - GENERAL INFORMATION

Q1. Type of Respondent

- ☐ Occupant (Owner)
- ☐ Member of Condominium Management

Q2. Type of Condominium

- ☐ Super Luxury Condominium
- ☐ Luxury Condominium
- ☐ Semi Luxury Condominium

Q3. Size of the Condominium

a. No of floors:…….
b. No of units in a floor:…….

Q4. Age of the Condominium

- ☐ 0-5 Years
- ☐ 6-10 Years
- ☐ 11-15 Years
- ☐ 16-20 Years

Q5. Effective period of usage of Condominium

a. Year of Completion:……
b. Year of commencing of functional operation:……

Q6. Maintenance of Condominium

- ☐ In house Committee
- ☐ Outsource to Maintenance Company

Q7. Registered with Condominium Management Authority (CMA)

a. Year of Registration:……
b. Does it presently Maintain by CMA:……

Q8. Location of the Condominium:……

NOTE: This research is focused on the defects which occurred after the Defect Liability Period (Latent defects occurred after building occupied)

SECTION B - FREQUENCY OF OCCURRENCE, SEVERITY AND REWORK/RECTIFICATION COST OF LATENT DEFECTS IN CONDOMINIUMS IN SRI LANKA

Q9. Have you noticed following latent defects in condominiums during the occupancy stage? If 'Yes' please tick ☑ into the check box according to the following scale.

1 - Never Occurred 2 - Slightly Occurred 3 - Moderately Occurred

4 - Frequently Occurred 5 - Very Frequently Occurred

No	Latent Defects in Condominiums	Frequency of Occurrence				
		1	**2**	**3**	**4**	**5**
1	Cracks	1	2	3	4	5
2	Water seepage	1	2	3	4	5
3	Delaminated tiles	1	2	3	4	5
4	Unevenness	1	2	3	4	5
5	Stains	1	2	3	4	5
6	Hollowness	1	2	3	4	5
7	Discolored tiles	1	2	3	4	5
8	Efflorescence	1	2	3	4	5
9	Spalling and Chip off	1	2	3	4	5
10	Corrosion of reinforcement	1	2	3	4	5
11	Paint discoloration	1	2	3	4	5
12	Peeling paint/blistering	1	2	3	4	5
13	Damaged/corroded ironmongeries	1	2	3	4	5
14	Non-alignment in doors and windows	1	2	3	4	5
15	Defects in sanitary wares	1	2	3	4	5
16	Pipe leaking	1	2	3	4	5
17	Functioning defect in service equipment (Fire, Lift, Air condition)	1	2	3	4	5
18	Biological attacks (Fungus/Algae),	1	2	3	4	5
19	Other if any, please specify	1	2	3	4	5

Q10. Please tick ☑ the severity (technical impact and early attention) of latent defects into the check boxes of the table according to the following scale

1- Not very severe 2 - Not severe 3 - Moderate Severe

4 - Severe 5 - Very severe

No	Latent Defects in Condominiums	Severity of Latent Defects				
		1	**2**	**3**	**4**	**5**
1	Cracks	1	2	3	4	5
2	Water seepage	1	2	3	4	5
3	Delaminated tiles	1	2	3	4	5
4	Unevenness	1	2	3	4	5
5	Stains	1	2	3	4	5
6	Hollowness	1	2	3	4	5
7	Discolored tiles	1	2	3	4	5
8	Efflorescence	1	2	3	4	5
9	Spalling and Chip off	1	2	3	4	5
10	Corrosion of reinforcement	1	2	3	4	5
11	Paint discoloration	1	2	3	4	5
12	Peeling paint/blistering	1	2	3	4	5
13	Damaged/corroded ironmongeries	1	2	3	4	5
14	Non-alignment in doors and windows	1	2	3	4	5
15	Defects in sanitary wares	1	2	3	4	5
16	Pipe leaking	1	2	3	4	5
17	Functioning defect in service equipment (Fire, Lift, Air condition)	1	2	3	4	5
18	Biological attacks (Fungus/Algae),	1	2	3	4	5
19	Other if any, please specify	1	2	3	4	5

Q11. Please tick ☑ the cost for rework/rectification of following latent defects into the check boxes of the table according to the following scale.

1–Very Low cost 2 - Low cost 3 - Moderate cost

4 - High cost 5 - Very high cost

No	Latent Defects in Condominiums	Rework/Rectification cost of Latent Defects				
		1	**2**	**3**	**4**	**5**
1	Cracks	1	2	3	4	5
2	Water seepage	1	2	3	4	5
3	Delaminated tiles	1	2	3	4	5
4	Unevenness	1	2	3	4	5
5	Stains	1	2	3	4	5
6	Hollowness	1	2	3	4	5
7	Discolored tiles	1	2	3	4	5
8	Efflorescence	1	2	3	4	5
9	Spalling and Chip off	1	2	3	4	5
10	Corrosion of reinforcement	1	2	3	4	5
11	Paint discoloration	1	2	3	4	5
12	Peeling paint/blistering	1	2	3	4	5
13	Damaged/corroded ironmongeries	1	2	3	4	5
14	Non-alignment in doors and windows	1	2	3	4	5
15	Defects in sanitary wares	1	2	3	4	5
16	Pipe leaking	1	2	3	4	5
17	Functioning defect in service equipment (Fire, Lift, Air condition)	1	2	3	4	5
18	Biological attacks (Fungus/Algae),	1	2	3	4	5
19	Other if any, please specify	1	2	3	4	5

Q12. If you identified latent defects in the following elements, please tick ☑ the element with relevant number according to the following scale.

1 - Never Occurred 2 - Slightly Occurred 3 - Moderately Occurred

4 - Frequently Occurred 5 - Very Frequently Occurred

Elements	**Frequency of Latent Defects in Elements**					**Remarks**
	1	**2**	**3**	**4**	**5**	
Floor	1	2	3	4	5	
Internal wall	1	2	3	4	5	
External wall	1	2	3	4	5	
Doors	1	2	3	4	5	
Window	1	2	3	4	5	
Ceiling	1	2	3	4	5	
Roofs	1	2	3	4	5	
Mechanical and electrical	1	2	3	4	5	
Plumbing and sanitary system	1	2	3	4	5	
Other if any, please specify.	1	2	3	4	5	

SECTION C - CAUSES OF LATENT DEFECTS IN CONDOMINIUMS IN SRI LANKA

Q13. Please tick ☑ the following causes of defects which you think that can cause the above mentioned latent defects in condominiums.

No	Causes of Latent Defects in Condominiums	Mark	Remarks
1	Use of poor quality construction materials		
2	Faults in design / design error		
3	Faults during construction		
4	Adverse climatic condition		
5	Polluted environment and dampness		
6	Lack of maintenance of condominium		
7	Lack of supervision of work		
8	Common natural hazarders		
9	Biological reasons		
10	Other if any, please specify..		

SECTION D - REMEDIAL MEASURES TO MITIGATE THE LATENT DEFECTS AND OTHER ISSUES IN CONDOMINIUMS

Q14. What are the remedial measures can be done to effectively mitigate the identified latent defects in condominiums?

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Q15. Please comment on other issues experienced in your condominiums and remedial measures

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… Thank You …