University of Southern Queensland

Identifying the Types and Causes of Construction Defects in Multi-Unit Dwellings

A dissertation submitted by

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Abstract

The aim of the project was to understand the types of defects occurring within residential apartment buildings over 3 stories in Australia. The need to undertake this work was highlighted through rapidly expanding numbers of apartment commencements in Australia over the last 15 years. Additionally, evidence suggests an increasing rate of defects through this period. By gaining a deeper understanding of the defects occurring, areas needing focus to prevent and minimise future defects can be highlighted.

A review of prior research outlined issues surrounding the availability of data on defects in apartments in Australia. The methodology used therefore considered the available sources of information with respect to the information sought, detail required and project time constraints. Accordingly, a mixed method was selected utilising a questionnaire of apartment residents accompanied by interviews with industry experts. The combination of these methods would provide the quantitative data required on defects, as well as insight from those within the industry. Analysis of the data collected would focus on the frequency and severity of defects to determine an overall defect risk profile. A review of all available apartment defect cause literature was also undertaken to review common causes.

The research found two defect types presented the highest overall risk – waterproofing and structural defects. In terms of risk profile, waterproofing defects were 1.9 standard deviations above the mean and structural defects were 1.37 standard deviations above the mean. It also found a secondary tier of risks to include electrical, light and data, hydraulics and corrosion. The expert interviews found the push towards Design and Construct (D&C) contracts for delivery of apartment buildings, reputation not being considered by buyers reliance on subcontractors to inspect and certify their own work and a lowering standard of engineering work were all raised as issues contributing to reduced apartment quality. The defect cause review found issues relating to information management and communications within apartment project teams. Other common defect causes identified were time pressures, workmanship, management strategy and motivation.

By identifying the defects creating the highest level of overall impacts and their relative significance, the study has highlighted to construction industry professionals and researchers areas where defect reduction activities and future research would provide the greatest benefit. In doing so, the frequency and severity of defect in apartments buildings can be reduced. The interview insights and defect cause review provide additional context to guide further work in this field.

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ENG4111/ENG4112 Research Project

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1 Introduction

1.1 Project Background

Apartments have become an increasing proportion of the total number of dwellings constructed each year in Australia. Shoory (2009) notes that apartment construction numbers were stable in Australia for 15 years up to 2009, before expanding dramatically in the years since. The Australian Bureau of Statistics (2020) also notes an 81.7% increase in the number of apartment commencements observed in the 15-year period between the 2004-05 and the 2018-19 financial years. Of this increase, the overwhelming growth has been in the form of mid-rise, high-rise and super-high-rise apartment construction (ABS, 2020). The construction of apartments is therefore now a significant and growing element of the construction sector and dwelling composition in Australia. The industry is also a major contributor to the Australian economy. As a sector, construction accounts for approximately 11% of Australia's Gross Domestic Product, and is responsible for employing approximately 9% of the workforce (Australian Bureau of Statistics, 2019).

Australian Dwelling Commencements Buildings 4 Storeys and Greater

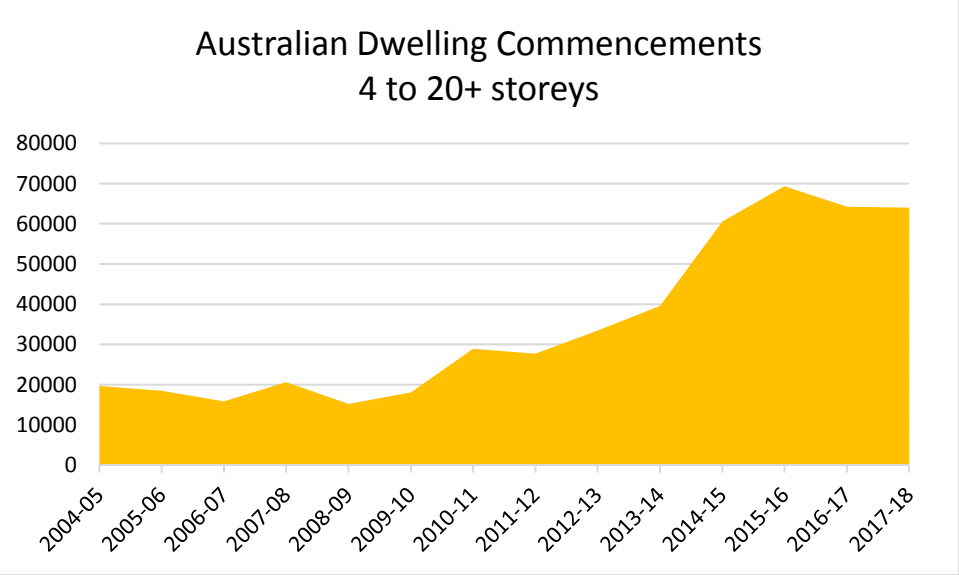


Figure 1.1: Australian dwelling commencements buildings 4 storeys and greater

Source: ABS, 2020

Against the backdrop of this growing sector, a growing issue of construction defects has been highlighted. Common issues relating to apartments include water ingress, cracking, poor energy consumption and noise insulation. A number of high-profile major defect issues in residential apartment projects including Opal Tower and Mascot Towers in Sydney have garnered significant

media attention, and highlighted to the public issues which are coming to the surface in the apartment construction sector. Residents of both these towers were ultimately evacuated due to safety issues within the buildings, with widespread implications for owners, the industry and regulatory bodies. These issues were compounded with the Grenfell Tower fire which occurred in the UK, leading to the identification of widespread flammable cladding issues in structures throughout Australia. These issues led to a number of investigations and reports into the construction sector, highlighting a variety of issues contributing to poor-quality outcomes for owners and residents. The outcome of the above was a reduced level of confidence in apartments being built and the apartment construction industry.

The impetus of the project was therefore to take a deeper look at the building industry, where the occurrence of defects appears to be widespread and growing – mid-rise and high-rise apartments, to identify and review what defects are occurring and what causes and factors may be contributing to the issues observed. Cromellin et al. (2021) note that unlike the house building sector, little research has been undertaken into the area of apartment defects. Given the changing trends of home ownership in Australia, more research is needed in this area to ensure the sustainability of apartments as a viable housing option.

The potential benefits in identifying these causes lies in highlighting their prevalence, to assist in targeted efforts to reduce their frequency and severity. The collection of defect information and other data will be done from the perspective of the end user, as the way the apartment performs its necessary functions will be most noticed by the user, and in turn any limitations in that performance or function will impact them. While the high-profile defect examples mentioned prior are major in nature, minor defects are much more widespread and as such will also be a focus of the project.

1.2 Project Aim

The aim of the project is to identify defect types occurring within apartments, either through historical defect data or new data collection and to review the severity and impacts. The formal outline of the project aims is as follows:

- Understand the historical research on construction defects in apartment buildings
- Develop a framework for analysing defects
- Collect and analyse defect data
- Determine defect risks and identify potential causes

1.3 Project Objectives

In order to achieve the outlined project goals and to achieve project success, the following objectives will need to be met:

- Review and develop understanding with regards to the apartment defects literature, particularly in regard to defect causes.
- Develop or adopt a classification structure for defect types.
- Identify the defect cause links from the literature and create a framework to attribute likely causes to common defect types.
- Identify the potential sources for apartment defect data and develop methods to obtain.
- Review and classify the defect data.
- Apply the framework of defect causation from the literature to the data, to assign likely causes.
- Evaluate and analyse the data to identify themes and trends.
- Summarise the findings and identify future research areas

1.4 Project Implications and Consequential Effects

While there has been growing impetus to look into the area of apartment defects in Australia, to date there has been little work to review the types of defects commonly identified, their severity and impacts. By reviewing the above, determinations can be made as to the best course of action for future work which can target defect reduction activities. Industry professionals can also gain greater insight as to where they may need to focus both managerial and quality assurance efforts for greatest effect.

Implications of these defects are also felt by residents of these dwelling types, and these will be represented to some extent from the data collection and existing data and research. By highlighting which issues are noted most frequently by residents, works can be focused on improving customer satisfaction for both developers and building management professionals. The data will also represent what is noticed most regularly by residents and has the largest impact on their habitation of a property. The findings of the report will also assist future research in this area.

2 Literature review

2.1 Introduction

The purpose of the literature review is to examine what work has been done previously which can contribute to the topic of defect identification, classification and prevention within multi-storey residential dwellings. While this paper will focus on construction within Australia and particularly over the past 20 years, the occurrence of defects within the construction industry is not a phenomenon which is recent or constrained geographically to one country or region. The learnings from literature published outside the specific scope of the paper can still provide a deep context on what defects are, why they occur and how the issue has been researched and studied previously. For this reason, a thorough review of the literature previously published within the area of construction defects will be undertaken. This review will primarily be focused on what research has been done to look at the causes and contributing factors to such defects. It will also look at the methodologies used in previous research with a particular focus on how and at what point of a building life defect data is collected. Lastly, it will review the various methods used to classify defects to assist in the creation of a defect categorisation framework.

2.2 Research Background

A number of key research methods and concepts delving into the issues surrounding quality issues within residential apartment builgings have been identified. The authors of these papers and their methods help to demonstrate differing perspectives on the topic as well as provide tools which can be applied in the context of the current project. Research undertaken by Atkinson (1999) into how human errors contribute to the occurrence of defects identified two key areas requiring future research – all forms of communications and the qualities of managers. Later research by Atkinson (2002) then created a conceptual model which demonstrated the differing effect timeframes and impacts of 'Primary' errors caused at the defect location, more remote project factors identified as 'Managerial' as well as even broader 'Global' factors within which the project operates. The further study again identified Managerial factors relating to communication as the highest ranked cause of error followed by time pressures, similar to the findings of Atkinson's prior research. It also correlated issues with poor formal communications between the study and other prior research (Atkinson, 2002).

In one of the key pieces of research on defect causes, Josephson and Hammarlund (1999) followed seven building projects to determine the causes of observed defects. The research highlighted the

impacts of a lack of motivation, and a lack of knowledge in being major contributing factors to defects.

Looking now to research done in Australia, and with a focus on multi-unit dwellings and defect issues within then, three key reports have been identified. A research report undertaken by Johnston & Reid (2019) looked at defects which occur in multi-owned properties, with a focus on the defect impacts, construction regulatory environment and how the defects are managed. As part of the research, building audit reports were collected to identify the types of defects occurring in these dwelling types. The research found that building fabric and cladding was the building element most impacted by defects, followed by fire protection and waterproofing. It also developed a building defects categorisation model to analyse the collected data.

Additionally, Two research reports have been published by the University of News South Wales' City Futures Research Centre, the first report titled 'Governing the Compact City' (UNSW, 2012) focused on issues relating to strata management including defect management. The second report was published in 2021 titled 'Cracks in the Compact City' (UNSW, 2021), and given the noted defect issues in the intervening period between the reports was primarily focused on defect issues in strata dwellings. The 2012 report noted major concerns with the impact of defects on strata communities, issues relating to responsibility limit identification due to complexity surrounding shared boundaries, and issues relating to the funding and planning of long-term maintenance activities for buildings. It also looked deeply into issues surrounding the management of information, which will be discussed in more detail later in the literature review. Primarily the review found issues relating to timely access to information for apartment purchasers, and these issues persist for owners after handover (UNSW, 2012). The 2021 report found a high incidence rate for defects in apartment buildings, and looked at defect types noting issues relating to water ingress and structural issues as the most common. It also identified significant issues surrounding the availability of information for prospective apartment purchasers, as well as broader issues around information for the industry. Lastly it looked at regulation issues, finding that government agencies have not been collected the required information which would provide the oversight required to minimise quality issues in these developments (UNSW, 2021).

A method for determining the importance of defect causes was created by Aljassmi et al. (2014) in order to assist in the prioritisation of defect prevention efforts. As defects can have a multitude of causes, it may also be necessary to rank these causes in terms of importance. The method was

created using importance measures and fault trees, looking at frequency and severity of causes to rank their risk to a project. These techniques may assist in determining how to allocate defects with multiple causes. A significant portion of the key prior research related to identifying defect causes and has been included in a separate section further below in the literature review.

2.3 Defects

It is necessary when reviewing issues of quality to properly define what constitutes quality and what factors may influence the determination of this definition. A suitable definition for quality is provided by the International Organization for Standardization (ISO), which states that quality is the 'totality of characteristics of a product, process, organization, person, activity or system that bear on its ability to satisfy stated or implied needs' (ISO, 1994). In order to meet the project objectives in determining defect causes, it is also necessary to understand and select a suitable definition for a defect. Defining terms such as 'defect' and 'quality' will also be necessary to guide participants in the data collection phase of the project. As is highlighted by Georgiou et al. (1999), there can be differing perceptions as to what may constitute a defect between the various stakeholders involved in the construction and operation of buildings. For the purposes of the research paper, it was noted that the definition provide by Watt was the most frequently referred to within papers reviewed as part of the literature review. Watt defines a defect as a 'term used to define a failing or shortcoming in the function, performance, statutory or user requirements of a building, and might manifest itself within the structure, fabric, services or other facilities of the affected building' (Watt 1999, p. 96). This definition will therefore be used where clarity is needed on what constitutes a defect, for example for data collection. The perception of what constitutes a defect may differ depending on data source, and as such categorisation of defect data collected will be undertaken as part of the project and not by the respondent. Guiding information to participants will include clear definitions and examples of types of defects that may represent the selectable categories within the data collection method.

2.4 Apartments

The target dwelling type for the research is to review defects within dwellings that are generally known in Australia as apartments or flats. The Australian Bureau of Statistics (2016) defines these two dwelling types in the same manner, noting they 'do not have private grounds and usually share a common entrance foyer or stairwell' (ABS, 2016). There are unique construction methodologies used in the construction of apartment buildings, necessitating their consideration separately to defect issues in other dwelling types such as freestanding houses, terraces or town houses. The

focus of the study on buildings four stories or greater means increased complexity relating to structural loads, utility services and materials, and these can increase the likelihood of defect creation. Additionally, commercial pressures relating to time and profit can incentivise activity in the construction of these buildings that can lead to substandard outcomes. Lastly, these dwelling types are often sold sight unseen to buyers, limiting the ability for prospective purchasers to inspect or gain an in depth understanding of what they are purchasing or to monitor the works as they progress. These information limitations are discussed in greater detail further below.

2.5 High-Profile Defective Apartments in Australia

A major contributor to recent attention brought to issues within the construction industry, and more specifically within high-rise residential construction has been a series of high-profile major defect incidents within residential apartment buildings. The primary examples of this in Australia were incidents which occurred at Opal Tower and Mascot Towers, which are both located in Sydney and both having suffered major structural defects. It was noted by Cromellin (2021) that whilst the NSW government was aware of issues within the apartment building sector, a strong push for noteworthy regulatory change did not occur until the Opal and Mascot Tower incidents occurred. A summary of the issues which occurred in each tower and the resulting response is provided below.

2.5.1 Mascot Towers Sydney

Mascot Towers is a 10-storey residential tower built within the Sydney suburb of Mascot which was completed in 2009. The structural defects within the building were identified during an engineering inspection undertaken in 2019, which noted significant safety concerns for residents as a result of cracking in structural elements of the building. The building was evacuated as a result of the discovery of these major defects and remains vacant to this time. Technical reports commissioned to review the causes for the defects at Mascot Towers have not been made public, however it has been reported that cracking had occurred within the building's key supports (Cromellin et al. 2021). Due to its age, the building was outside of the statutory warranty period. Additionally, the developer had collapsed due to financial issues prior to the discovery of the major defects. Residents therefore had little recourse in rectifying the building defects and were unable to inhabit the property. The NSW Government subsequently introduced an assistance package for owners and residents of the tower, to cover emergency accommodation costs until the building rectification works could be completed. Legal issues surrounding the development have to date hampered the resolution of the defects and reoccupation of the building.

2.5.2 Opal Tower Sydney

Opal Tower is a 36-floor residential tower built within Sydney's Olympic Park which was completed in August 2018. In December 2018 a loud 'crack' was heard by residents, which was later discovered to be the cracking of a concrete structural element of the building. This incident led to the evacuation of the almost 3,000 residents of the building due to fear of collapse. These series of events prompted the NSW Government to commission an independent report into the incident. The purpose of the report was to ascertain the cause of the structural issues within the tower, to determine potential remedial actions as well as to provide recommendations in regard to how similar issues could be avoided in future high-rise construction projects (Unisearch, 2019). The report found that both design and construction issue were contributing factors to the major structural defects within the building. More specifically the report noted that hob beams within the building were under-designed, that short-cuts were made in construction processes through reduced grouting, and material deficiencies were also observed to contribute to the failure (Unisearch, 2019).

Figure 2.1: An example of a damaged hob beam - Opal Tower

Source: Unisearch, 2019

More critical to analyse are the report recommendations as to how to avoid incidents of this nature in future. Five recommendations were made, which are summarised as follows:

- Register engineers through a government database.
- Third party checks of designs and design changes.
- Checks to be conducted during key stages to ensure construction is as per design.

- Creation of an online system detailing certifications for buildings, accessible to key building stakeholders.
- Creation of a review board tasked with investigating and reporting structural damage to building caused by design and construction. (Unisearch, 2019).

2.6 Government-commissioned Reports responding to the Defect Crisis

Since compliance and enforcement issues within the industry were highlighted by the Grenfell Tower fire which occurred in the UK in June 2017, government agencies have produced a myriad of reports into quality issues within the construction industry. The Grenfell Tower fire was attributed partly to flammable cladding applied to the structure which facilitated spread of the fire, prompting a wave of reports into similar cladding products used in commercial and residential buildings across Australia. A second phase of reports were commissioned after the Opal Tower and Mascot Towers in Sydney experienced their major structural issues. A review and summary of these government reports produced over the previous 5-year period is provided below.

A report was commissioned by the Australian Senate in June 2015, relating to issues of non-conforming building products. The request was referred to the Economic References Committee, who later updated the report requirements in August 2017 to provide a specific interim report on issues of flammable cladding. The report made 8 recommendations including bans for specific cladding products, creation of a national licensing scheme and making Australian Standards and codes available free of charge (Senate Economic References Committee, 2017).

Several state government reports were also commissioned as a result of issues surrounding non-compliant flammable cladding. These included the 2017 Victorian cladding taskforce report, 2018 Tasmanian aluminium composite panel audit and the 2018 Queensland Non-Conforming Building Products Audit Taskforce Status Report. These reports provided recommendations on establishing registers of buildings with flammable cladding issues, they also helped in the creation of regulatory frameworks to facilitate and deliver the remediation works required to government and private buildings.

The Building Ministers Forum (BMF) commissioned a report in June 2017 to review issues observed in the implementation of the National Construction Code, particularly with regards to compliance and enforcement. The BMF is tasked with oversight of matters relating to regulation and creation of policy for the Australian construction and building sector. Federal and state governments and

other stakeholders were consulted as part of the report. 24 recommendations were provided across 10 theme areas. Key to these themes were accessibility and sharing of building information, training and registration of building professionals and improved regulatory oversight. (Shergold & Weir, 2018)

In the period since the major defect incidents at Opal Tower and Mascot Towers in Sydney, several reports have been commissioned to analyse quality issues in the construction and management of apartments buildings, and to identify issues surrounding the growing incidence of defects. One such report was commissioned by the NSW Government in 2020, which primarily focused on issues of flammable cladding. The report also focused on reviewing how strata committees respond to defects and issues surrounding building certification. The report highlighted the extent of the defect problem in apartments in NSW, noting issues in obtaining defect data and in accessing information on defects as a prospective apartment purchaser. The report recommended a number of regulatory changes including improvements surrounding inspections, identifying non-compliant products and accessibility of data including a public register for buildings with flammable cladding issues (NSW Parliament Legislative Council, 2020).

A subsequent report was completed as a joint undertaking between the NSW State Government and the Strata Community Association of NSW in late 2021. The purpose of the report was to review serious defects in strata buildings which had recently been completed, to determine their frequency and severity. Criteria for inclusion of buildings were those over 4 stories in height and completed within the last 6 years. The report found 39% of buildings surveyed had undergone some form of serious defect, with waterproofing issues the most frequently observed at 34%, fire safety systems at 20% and structural-related issues at 14%. The report also gave insight into defect identification with 51% of defects identified through independent inspections and 37% directly from residents. More generally the report found significant financial and emotional impacts of defects and the resolution process for residents. It also highlighted the challenges for strata agencies in responding to defects, including obtaining consensus amongst owners when responding to defects and arranging rectification works and dealing with legal challenges (NSW Government & SCA NSW, 2021). A summary of reports looking into building quality issues in Australia since 2017 is included in Table 2.1 below.

Summary of Reports into Building Quality Issues in Australia Since 2017

Report Title	Commissioned By	Date	Aims
Non-conforming building products Interim report: aluminium composite cladding	Australian Federal Government	September 2017	Non-conforming building products, flammable cladding
2017 Victorian cladding taskforce report	Victorian State Government	November 2017	Investigate non-conforming cladding products on buildings
2018 Tasmanian aluminium composite panel audit	Tasmanian State Government	January 2018	Audit of all aluminium composite cladding in Tasmania
Building Confidence: Improving the effectiveness of compliance and enforcement systems for the building and construction industry across Australia	Building Ministers' Forum (BMF)	February 2018	Compliance and enforcement in construction
Queensland Non-Conforming Building Products Audit Taskforce Status Report	Queensland Government	April 2018	Review potential non-conforming conbustible cladding
Regulation of building standards, building quality and building disputes	NSW Government	April 2020	Flammable cladding, defects response, building certification
Research report on serious defects in recently completed strata buildings across New South Wales	NSW Government, Strata Community Association NSW	September 2021	Review serious defects, buildings >4 storeys

Table 2.1 - Summary of Reports into Building Quality Issues in Australia Since 2017

2.7 Other Reports addressing the Defect Crisis

In addition to the state government reports responding to the growing issues in the sector, a number of reports were also completed by researchers, research groups and industry groups. The construction union CFMEU commissioned one such report which was completed in 2019, titled 'Shaky Foundations: The National Crisis in Construction'. The research identified the cost of rectifying defects in apartments constructed between 2009 and 2019 as $6.2 billion, and that rising insurance costs, costs over-runs and delays related to defects will impede industry activity and growth without immediate action (CFMEU, 2019). Poor regulatory oversight has been highlighted throughout the report as a key driver in the reduction of apartment standards. Additionally, lack of oversight and prevalence of private certification are noted as contributing to outcomes of poor-quality apartments for eventual owners. Reports undertaken by Johnston & Reid (2019) and UNSW (2021) were also motivated by observation of these issues in the industry, and will be discussed in other areas of the literature review.

2.8 Information Management

The construction and maintenance of large apartment buildings requires that significant volumes of information are created, transferred and maintained. In order to operate and manage buildings effectively, building managers require access to a detailed set of documents outlining all key building information from the developer. This information includes the as-constructed plans for the buildings, information on plant and systems, maintenance and inspection records amongst others. Access to critical building information is also necessary for prospective apartment purchasers to undertake their due diligence before buying into an apartment building. Typically, information sourcing in regard to defects for prospective owners would take the form of accessing copies of strata minutes, inspections and reports. Recent defect issues have however highlighted the limitations of this approach. The NSW Government & SCA NSW (2021) undertook a survey of strata managers to review issues surrounding information, which noted limitations in the availability of key building information. These information limitations are demonstrated by less than half of the 1400 strata managers surveyed having access to as-built drawings for the property, as well as many other key building documents as outlined in Figure 2.2 below.

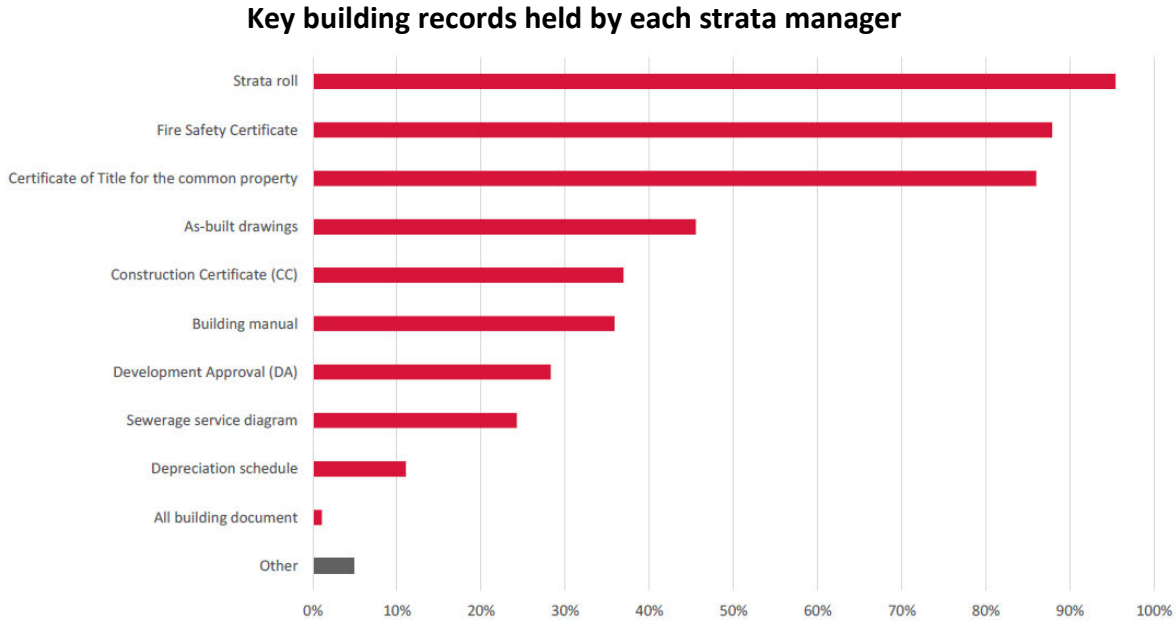


Figure 2.2: Key building records held by each strata manager

Source: NSW Government & SCA NSW, 2021

Two of the recommendations of the Building Confidence report (Shergold & Weir, 2018) focused on how building information is collected and shared and how post-construction information is managed. A central database of building information was recommended by the report to provide

regulatory functions and inform owners and prospective owners. Creation of a 'digital building manual' was also recommended for completed buildings, to compile documentation on design, maintenance and inspections. Clarity and access to information was a noteworthy theme and as such its impact must be considered when reviewing apartment defects.

2.9 Mid-Rise and High-Rise

The decision was made in the initial stages of the project to focus on buildings considered to be 'mid-rise' and 'high-rise'. There are a number of reasons for this, namely the increased complexity in design and construction, increasing numbers of these types of development projects as referenced in the project background, and the increasing profile of defects in these types of buildings. The Australian Bureau of Statistics (2020) notes an increase in the number of dwelling approvals for buildings greater than four storeys from '29,695 in the 2012-13 financial year to a peak of 72,258 in the 2015-16 financial year' (ABS, 2020). These types of dwellings are also becoming one of the most common forms of property as noted by Johnston & Reid (2019), with over 2 million residents now living in multi-unit dwellings in Australia. The definition used to identify building as 'mid or high-rise' will be in line with the Functional Classification of Buildings (FCB) outlined by the Australian Bureau of Statistics (ABS, 2001). Under the FCB, these types of buildings are defined as 'Apartments in a four to eight storey block' and 'Apartments in a nine or more-storey block'. Data collected and analysed for the study and used as the basis for data collection and in defect cause identification from the literature review will therefore be limited to structures four storeys or greater, except where specified. This will target the review to areas with the highest growth and most frequent occurrence of defects, increasing the potential project benefits.

2.10 Naming and Classification Systems

In order for defects to be analysed, a system needs to be adopted or created for naming and classifying them. Additionally, a lexicon will need to be adopted to describe terms relating to apartments, their systems and construction. Johnston & Reid (2019) noted that despite efforts made in previous research, no consistent classification method or methods of analysis or enquiry were available or had been used. These findings are reinforced by Sommerville (2007), who noted confusion in the realm of construction defect research due to a lack of common naming convention in describing common terms and phrases. This lack of consistency in naming structures is a limiting factor in comparing and contrasting the available research. Sommerville (2007) also notes that despite significant research into the area of construction defects over the previous 25 years, nothing has been done to unite the works into a coordinated 'coherent whole' from which future

research could be based. Creating a unified naming and classification system will therefore be a key task in the project, setting the framework for the defect and cause analysis. This framework will be key to the data collection phase of the project, guiding participants in the allocation of defect types, severity and other key collection areas.

2.11 Post-Construction Defects

One of the key decisions of the study was at which stage of the building lifecycle to focus defect identification and data collection. It could be argued that defect prevention during the construction phase of a building could have an oversized impact on future issues. Alternatively, a strong case can be made for reviewing post-construction defects in apartments given their impact on residents, and given this phase will represent the overwhelming majority of the building's expected lifespan. Johnston & Reid (2019) and Atkinson (2002) noted apartment defects had hidden or latent factors which often made them unobservable during the construction phase of a project. The phenomenon of hidden or latent defects only appearing during the occupancy phase of a building was also noted by Chong and Low (2006). Data availability must also be considered, and given the above factors and the time noted for some defect types to appear the decision was made to focus on the collection of information during the post-construction period. This choice also serves to focus defect analysis on those defects which present most frequently and have the most impact upon the residents of the properties.

2.12 Multi-Unit Dwelling Factors

Several factors were identified in relation to the likelihood of defects occurring which were specific-to or observed in increased rates in apartments when compared to freestanding dwellings. Forcada et al. (2012) observed that a higher number of defects were noted in apartments than in freestanding houses, attributing this in part to the lack of client input in apartment construction, and their limited role in creating the brief of needs for their apartment. Additional factors were highlighted by Atkinson (1999) in regard to the repetitive nature of work on apartments, the stricter timeframes for their construction and the higher pressure of the work environment all contributing to an increased likelihood of defects in these dwelling types. Another factor distinct to this high volume and complex method of construction were the high levels of subcontracting utilised, requiring large and complex means of supervision and authority which can obstruct decision making and communication (Tam et al. 2011). The passing of work between trades is an additional generation source for defects, as subsequent trades can inherit the incomplete or incorrect work of the previous without the information to identify and prevent the spread of defective works. This

interface is also a point for issues of accountability between subcontractors, and the high levels of subcontracting of work in the industry exacerbate these sources of potential defect generation.

2.13 Information Availability and Access

A common theme noted amongst previous research was that availability and access to information for apartment stakeholders was a significant issue for the residential apartment sector. The University of New South Wales (UNSW, 2012) prepared a report on the governance of multi-unit dwellings which looked at the issue of data availability with regard to qualitative defect data. It found that contributing to these issues was the fact that data relating to building defects was held between more than a dozen differing building stakeholders including governments, contractors and certifiers. Therefore, in order to create a broad database of defects it would be necessary to navigate negotiating access and confidentiality matters with all of these parties. The number of differing parties holding elements of information relating to defects also creates issues of data consistency. The way data is presented, the target audience, the expertise and focus of the collector and author of the information all lead the inconsistencies across these potential data sources. Lastly, the report found that as many defect areas cannot be inspected visually, inspections frequently were not thorough enough to provide a comprehensive source of information.

Example of Inconsistency in Defect Data Collection

	Classification of defects								
Kind of defects	Defect Report 1	Defect Report 2			Defect Report 3			Defect Report 4	
	Defect	Condition Rating 1	Condition Rating 2	Condition Rating 3	High Priority	Medium Priority	Low Priority	Defects	Minor Defects
Crack	☑	☑	☑		☑	☑		☑	☑
Tile damage	☑		☑	☑		☑			☑
Blocked weephole	☑	☑			☑			☑	
Water penetration	☑	☑			☑				

Figure 2.3 - Example of Inconsistency in Defect Data Collection

Source: Crommelin et al. 2021

A subsequent report by Crommelin et al. in 2021 delved into greater detail in information movement through the sector not just relating to defects, but in the purchasing and sale of

apartments, inspections and regulation and during design and construction. It noted that customers for apartments in these buildings are particularly vulnerable, given the large imbalance in information and financial power they have when compared to developers. This issue is compounded by the fact that no parties within the process are incentivised to provide building information to these prospective purchasers. The current method for obtaining information on a building for purchasers is via the strata report, however due to limited regulation the quality and comprehensiveness of these reports can differ substantially. This information source is also not available for purchasers of new apartments, and in these instances the purchaser must rely on information supplied by the developer, and issues in the balance of power and incentive structure between these parties can impact the suitability of the information provided.

The report also noted that checks and auditing for developers were often the first processes to fall when time and cost pressures were observed, and that despite developers being best positioned to collect such information there is currently a disincentive to do this due to commercial pressures. Information issues are also common in the tendering and design phases of these buildings, with the report noting that buildings commenced with inadequate design and documentation – particularly for Design and Construct (D&C) contracts also impacted the quality of built outcomes. Ultimately the report summarised these issues in information as being due to commercial pressures of time and profit, a lack of care and skill for the involved parties and a lack of sufficient oversight from regulatory agencies. Recommendations include that developers should be required to provide standardised, in-depth information for purchasers. It also noted better training and improving the quality of strata management would provide significant assistance to apartment owners in accessing reliable and relevant information relating to their building (UNSW, 2021).

2.14 Regulatory Oversight

While the issue of regulation within the apartment industry is not a primary focus for this research, it is necessary to provide context from the literature on the subject of regulatory oversight. Issues relating to how regulation has contributed to poor quality outcomes in the industry are discussed in a number of reports which have been reviewed. The most comprehensive of which is a report by UNSW in 2021 which notes that governments themselves are also subject to the information access limitations discussed in section 2.13, and that a lack of reporting requirements for developers to government was limiting their ability to effectively regulate the industry. It also highlighted that the push towards deregulation of the industry in recent decades has had a detrimental impact on the ability of government to monitor and ensure proper performance. The belief that the industry

would self-regulate and become more efficient was noted to have not occurred as feedback loops through sectors such as project financing and insurance did not prevent the occurrence of poor-quality apartment buildings. Sharing of information between government agencies has also been poor, and a push towards a shared digitised system is necessary to help prevent these issues recurring moving forward (UNSW, 2021).

2.15 Causality

The basis for identifying causes of construction defects and the value in reviewing these is presented in part by Pearl (2009), and his method for explaining causality which surmises that if 'X is a cause of Y, if we can change Y by manipulating X' (Pearl, 2009). The need to review defect causes as part of the study is reiterated by Aljassmi et al. (2016), who notes that it is an essential element in defect minimisation to determine and review the defect causes. They also argue that root causes of defects contribute the majority of the impetus for defect creation and as such addressing these root causes will also provide the greatest benefit in terms of minimisation. The value of addressing defect creation through identifying their causes is therefore demonstrated. Due to practical considerations experimental data which could specifically detail causal links cannot be undertaken, and as such the analysis of potential defect causes will be based on a review and summary of all available historical research on apartment defect causes. The review will identify common causes to be considered in defect reduction activities and future research.

2.16 Impacts

The impacts created by defects can have broad-reaching effects to all those involved in the industry, from the construction to occupation of a building. In the research report published by Johnston & Reid (2019), issues relating to health impacts caused by defects within residential dwellings were raised. These concerns related to both physical health implications for residents – for example due to mould caused by water ingress, as well as concerns relating to the physiological impacts which can be caused by financial concerns, safety concerns and other factors. In addition to the human impacts, defects can cause significant direct and indirect costs. Marosszeky et al. (2002) notes that indirect costs relating to defects can have an equivalent impact as the direct costs. The costs to rectify defects can be significant in these building types, and this is demonstrated by Figure 2.4 which shows the costs of rectifying defects from case law in New South Wales apartment buildings between 1999 and 2000.

Figure 2.4: Costs to Rectify Defects from Case Law in NSW Apartment Buildings 1999-2020

Source: Crommelin et al., 2021

Others however have noted an even greater impact from indirect costs which can go unnoticed due to increased difficulty of attribution and capture. Love (2002) argues that indirect defect costs can be as much as five times those of the direct costs. The impetus for further research in the area of defect impacts is demonstrated by the above, particularly noting the growing numbers of apartments being constructed in Australia and the increasing incidence of defects observed.

2.17 Common Defect Types

In order to provide insight which can aid defect minimisation, it is first necessary to research and identify common defect types. A list of the most common defect types is necessary to ensure accurate and efficient data collection, providing sufficient options for all defects to be accurately categorised in the data collection whilst providing the necessary level of detail. The issues in establishing such a list is noted by Karim et al. (2006), who highlights that limited research has been undertaken to create a definitive list of defects and their causes. Attempts have been made however to create a system for categorising defects. One such system was created by Georgiou et al. (1999) which comprised of 12 types of defects - for example drainage, external leaks and structural adequacy, as well as 35 building system elements which were broken down into 8 broader categories generally by trade (carpentry, plumbing etc.). While this example pertains specifically to residential home construction, similar attempts have been made larger apartment buildings. Johnston & Reid (2019) created a matrix of building defects for apartments by analysing building defect reports with her research team, defining defect types through 13 construction systems such as building cladding, fire protection and structural. Selection of the most appropriate

categorisation method will consider the prior research in order to create a defect categorisation scheme that is user friendly while still containing sufficient detail for the required analysis.

2.18 Causes and Contributing Factors

A significant portion of the research identified in the literature review and relevant to this research pertains to defect causes. It is important to firstly note that defects can have many causes, as noted by Josephson and Hammarlund (1999) in one of the key pieces of research in this area. Josephson and Hammarlund (1999) monitored 7 building projects over 6 months, with observers collecting data on almost 3000 defects. They noted that causes can be difficult to attribute, however that direct causes are typically assigned to individuals, though working under the influence of wider project conditions (Josephson and Hammarlund, 1999). They also noted that individuals often had the requisite knowledge and information required, but lacked sufficient motivation, leading to defects (Josephson and Hammarlund, 1999). The study conducted by Atkinson (2002) looked at the influence of human error in defect creation and identified a link between defects and management methods. A review focused on defects occurring post-construction was also undertaken by Porteous (1992), which identified human error and environmental exposure as the two primary causes of defects in completed buildings. The impact of the project delivery environment was also identified as a contributing issue in studies by Jingmond and Ågren (2015), which recommended that defect prevention efforts should focus on the managerial and strategic levels of project delivery and not at the level of the individual. Wider industry trends such as a 'boom' period can also influence the incidence of errors, noting the significant increase in the volume of unit construction noted earlier in this report. Observations on this phenomenon were made by Forcada et al. (2012) in regard to the Spanish housing industry in the late 1990s and early 2000s, whereby a housing boom led to substantial inexperience in the industry, resulting in declining quality. While this level of analysis is outside the scope of this report, it is an important and interesting consideration on the impact of the broader industry environment.

Cromellin et al. (2021) notes that the method of construction and delivery for apartment developments can contribute to the generation of defects. Key to those issues identified is that purchasers of apartments generally have very little input or oversight in the completed property. Instead the buyers must rely on oversight from government agencies, private certifiers and the subcontractors themselves to ensure the work is done to the required standards. The report also notes that buyers have very limited access to information, making it difficult to identify quality issues within the property (Cromellin et al. 2021).

2.19 Summary

The literature review served to provide a strong basis of knowledge on apartment defects which will assist in guiding this research. The research background highlighted the importance of considering the levels at which defects and their causes may occur, in regard to operational, managerial and global. Many of the studies highlighted the significant influence of managerial and global elements on defect creation. Issues relating to poor communication both internally and externally were highlighted as defect causes by multiple studies It was also noted the specific nature of the prevalence of defects in multi-unit dwellings, and the aspects unique to their delivery and management that can influence these issues. These findings reinforce the decision to focus on mid- and high-rise structures, and guide areas of further enquiry. A need was also highlighted from the review to create a consistent and suitable naming and classifying scheme for data around defects and causes, which can be based on those from the previous research. Another key finding of the review was that information availability for apartment purchasers was poor, and the imbalance of information access and power between the buyer and seller was a factor in poor quality outcomes. Broader issues in information access and flow were also highlighted, with developers not providing sufficient information to building managers, governments not collecting sufficient data to oversee industry activities, and inconsistency in collection methods and standards across most areas of data management.

Other areas of note were centred around the review of identified defect causes. These causes focused on three major elements, those human-related, management and project delivery environment related and global. The consistency around findings provides a strong basis from which new defect data can be analysed using the historical research on causes. The research paper will assist in reviewing defect causes and current defects observed in these building types.

3 Research Design and Methodology

3.1 Introduction

The purpose of the project methodology is to outline the selected approach to undertaking the project work and achieving the stated project objectives. In addition to this, it is necessary to explain the reasons as to why the methodology was selected when considering other potential methods. In order to do this, the broader process of initial topic selection, initial research, identifying the knowledge gap and developing the project brief will be outlined to aid in explaining the method selection. The methodology will then be outlined in detail and explained in the context of the broader project and how it will address the research question and therefore achieve project success.

In order to fully meet the project objectives, it was determined that both quantitative and qualitative methods were required. To explain why particular the particular mix of methods was selected it is first necessary to outline the considerations. Bickman and Rog (2008) note that the available resources are key to determining both the researchable questions as well as the selected methodology, highlighting the need for trade-offs in both these areas to meet both timeframes and resource constraints. The limited availability of data was apparent from the literature review and reinforced through initial approaches for access to existing data sets. This highlighted the need for a research design primarily based on the collection of new data.

In order to address the research question, the design and data collection methods needed to be feasible and minimise trade-offs. An online questionnaire was selected as it suited the type of information required, due to the ability to reach a high number of respondents and to improve the response rate due to ease of access and convenience for participants. The quantitative defect data to be collected includes the type, frequency, severity of defects and will be supplemented with experiential data from the respondents. The supplemental use of this type of qualitative data provides an additional level of information directly from the apartment occupant, allowing greater insight into the complex factors surrounding defects (Miles and Huberman, 1994).

3.2 Research Methodology

An outline of the research methodology is provided below:

1. Seek access to existing defect data

2. Identify and select suitable data collection methods to ensure collection of relevant and necessary data
3. Design data collection methods i.e. survey and interview questions and obtain ethical approvals
4. Undertake data collection focusing on owners and tenants for defect data and industry professionals for interviews
5. Collate data from available sources and categorise for analysis based on literature review categorization method selected
6. Review themes and trends in data and compare and contrast with any existing data collected
7. Analyse data with focus on theme and trend areas to create insight into defect causes and contributors
8. Analyse contributing factors from the project environment, construction activities and mechanisms of defect creation
9. Compare data findings with literature review findings, analyse commonality and variances
10. Provide conclusions based on data analysis and research findings
11. Identify prospective areas of future research

3.3 Project Development

The genesis of the research began with increasing public coverage of residential high-rise buildings with major defect issues. The two highest-profile of these in Australia being Mascot Towers and Opal Tower, both located in Sydney. Additionally, there was a growing perception both in media and anecdotally that the quality of modern apartments was increasingly poor, to the point where modern apartments were discouraged by those providing advice to prospective buyers. Initial research into the area of apartment defects found notable issues both on the topic of the defects themselves and in the research and data available to review the topic.

From the initial research it was identified that little specific research had been done on defects and their impacts for the Australian apartment sector. It was also noted that despite the major structural defects drawing attention to the apartment sector, minor defects were significantly more common and thus had a greater overall impact on residents and the perceptions surrounding apartment quality. The project brief was then developed to pursue the identification of defects and contributing factors that were impacting apartment occupants. The determination was made that

by focusing defects with the highest impacts, future research could be undertaken to review methods to minimise them.

3.4 Literature Review

In order to properly address the research question, it was necessary to undertake an extensive literature review. The review primarily centred around the issue of building defects and their causes, however a number of related topics were also reviewed including the broader context of apartment construction in Australia as well as building and construction regulation. Limited Australian-based research was available on the topic hence international studies were also reviewed.

It was determined that the most appropriate research material to review would be peer-reviewed journals, focusing on those with high levels of citations. Papers by research groups and government agencies were also reviewed, provided they were suitable and relevant. Articles and papers selected were then evaluated using the five criteria recommended by Flateby and Fehr (2008), which are summarised below:

- Author experience and credentials
- Coherent and direct demonstration of ideas
- High quality of evidence
- Necessary quantity of evidence
- Quality of writing and presentation (Flateby and Fehr, 2008)

Published reports were also identified as a necessary source of project material, as a number of government and private reports were commissioned as a result of the public outcry from the Opal Tower and Mascot Towers issues which specifically addressed issues surrounding apartment defects.

3.4.1 Literature Review Methodology

An outline of the literature review methodology is provided below:

1. The methodology for the literature review involved first identifying the types of research sought in order to determine the most suitable databases to search.
2. Keyword determinations were then made for searches, focusing on defects, apartments, construction, quality management and related terms.

3. Articles were then identified and catalogued, noting key elements such as focus area (i.e. defects, quality etc.) as well as information on authors, citations and other key details.
4. Each article was then read, and a short summary written focusing on the methods and findings. Additionally, key information pieces were highlighted for further review and the number of key information pieces in each paper noted.
5. Articles with low relevance or of insufficient quality were discarded, and the remaining articles grouped by both quality/relevance and overarching topic.
6. The overarching topics and key information pieces led to the topic areas for each section of the review and were considered for the further development of the project.

3.5 Research Method

The research topic will require a theoretical analysis, connecting existing research and data with new data collection to provide outcomes and recommendations. The literature review will explore and collect information on the causes of defects, while new data collection will provide information on the defects currently being observed. A research method is therefore required to collect the defect data, with consideration to data availability, resourcing, reliability and volume of data required.

The online questionnaire method was selected as it provided the best balance between obtaining research objectives with the least trade-offs. Methods such as interview are time consuming and cannot easily be scaled, meaning very few participants could be interviewed. Observation or focus group would also not be suitable to collect defect information, as they would rely on chance to observe defects taking place or in the case of focus group, knowledge and experience of defects of those taking part. The greatest likelihood of finding defect information was determined to be by reaching those in the targeted property type and seeking their experience and observations. The most effective method in reaching large numbers of apartment residents was via an online questionnaire. By placing the questionnaire online, no large mail-outs are required to be received or sent, and access can be shared via a simple link provided either physically or electronically. This means large numbers of respondents in suitable property types can be sent access links, and a uniform questionnaire type can be used for all participants.

The type of data required is also a consideration. As noted by Mintzberg (1979), the collection of quantitative data without the added context of anecdotes can create difficulties in explaining the results. For this reason, the decision was made to collect additional information and context

through interviews conducted with industry members involved in the construction and management of apartment buildings. These interviews will provide qualitative context for the defect data collected through the online questionnaire. Additionally, the online questionnaire will provide several response areas allowing free-form responses from residents, capturing greater insight on the perspective of the apartment occupant in regard to any defects reported. The supplemental use of this type of qualitative data provides an additional level of information directly from the apartment occupant, allowing greater insight into the complex factors surrounding defect creation and management (Miles and Huberman, 1994).

3.6 Defect Cause Analysis

A summary of the papers analysed with regards to apartment defect causes is included in Table 3.1 below, focusing on the methods used and findings:

Author	Paper	Methods	Key Findings
Josephson, PE & Hammarlund, Y 1999	The causes and costs of defects in construction A study of seven building projects	Utilised observers on building projects over a 6-month period to review defects caused during production. Observers were engineers and had full access to sites and documentation, registering each defect and collecting data on causes, actions, consequences etc.	The study determined that motivation could be attributed for an average of 50% of the average defect cost across the projects, with knowledge the second largest factor at 29%. Root causes were also studied, identifying time and cost pressures, stability of teams, project control and support.
Jingmond, M & Ågren, R 2015	Unravelling causes of defects in construction	Workshops were undertaken with a variety of construction industry members, utilising cognitive mapping to find process causality. The method intends to link cause and effect in a step by step basis.	The study created a web of cause and effect, identifying the organisation as the main concern. This issue was broken down into more detail, finding endogenous organisational factors the main defect cause.
Johnston, N & Reid, S 2019	Examing Building Defetcs Research Report	Industry Reference Groups were used to design and inform the study. Building defect audit reports were collected from building consulting and auditing companies. Stakeholder and end-user surveys were then undertaken.	The study found 85% of all buildings analysed had defects. The categorisation of defects found 40% occurred in 'Building Fabric and Cladding', fire protection 13% and waterproofing 11%. A high proportion of defects were a consequence of water ingress.
Aljassmi, H, Han, S & Davis, S 2016	Analysis of the Complex Mechanisms of Defect Generation in Construction Projects	Data clustering and classification allocation techniques were used to review defect cause categories from previous studies, creating nine 'defective act clusters' with which to categorise defect causes. A database of defects was used to evaluate the defect classifications.	The study found two main themes of defective acts were 'skill-based errors and violations' whereby the skill-based errors relate to worker error, and violations relate to task sequencing and defective materials.
Chong, W & Low, SP 2005	Assessment of Defects at Construction and Occupancy Stages	Defect data was collected from building projects during both the construction and occupancy stages. Government data was used for the construction defect information. Occupancy defect data was collected from property manager repair and maintenance logs, as well as walkthroughs with researchers.	Different types of defects were observed at the construction and occupancy stages. Construction-stage defects were related to workmanship and protection issues during construction. Material defects were more likely observed during occupancy due to development time. Maintenance issues were also identified to have caused floor defects post-occupation.

Jonsson, AZ & Gunnelin, RH 2019	Defects in newly constructed residential buildings: owners' perspective	Data was collected via questionnaires sent to the chairperson of every residential estate built in Sweden between 2008 and 2013. The questionnaire looked at building details, property management, handover and commissioning, construction quality and knowledge of the cooperative board.	The most common building defects reported were those effecting the building envelope, waterproofing and weather-proofing. Issues were also identified with HVAC installations. The study also found issues with separation between construction and operation of buildings, limiting the sharing of information back into the design.
Forcada et al. (2012)	Influence of Building Type on Post-Handover Defects in Housing	Data was collected via client complaint forms, focusing on defects observed post-handover and whether these were influenced by construction type. Building and defect information was the focus of the data collection, which used 95 forms from both flats and houses.	Owners of new buildings were more aware of non-functioning elements and aesthetic issues. Owners identified differing types and larger numbers of defects in flats than houses. This was due to a lesser connection between contractor and owner, more task repetition and tight timeframes.
Chong, W & Low, SP 2006	Latent Building Defects: Causes and Design Strategies to Prevent Them	Defects data was collected from buildings 2-6 years in age, utilising records from property managers. Interviews and guided inspections of properties were also used to supplement this data. The data analysis focused on failure mechanisms of defects.	A lack of design feedback was observed which led to repetition of defect types. The use of feedback from building maintainers was an unused source of potential improvement. Preference was also observed to use existing methods and techniques and a reluctance to investigate or adopt new methods.
Karim, K, Marosszeky, M & Davis, S 2006	Managing subcontractor supply chain for quality in construction	Three construction projects were selected as part of the review. These projects were analysed using site observations, analysis of documentation and interviews with personnel. The fit-out and finish stage was analysed due to the preferences of contractors involved.	The study noted the distinct lack of focus on the area of subcontractors and their role in the creation of defects, despite subcontractors typically completing up to 90% of work. A tool was created to assist project staff in identifying key points within the subcontract chain where defects are likely to create cost and schedule impacts.
Atkinson, AR 2002	The pathology of building defects; a human error approach	An observational study was undertaken by the author, on a single construction site consisting of 61 freestanding houses under construction. The author integrated themselves as a contact point by taking all phone communications during the study period. Event notes were logged in a diary, and defects were noted with cause categories for analysis.	The study concurred with those previous studies in that managerial errors, and particularly errors in the area of communications were major causes of defects. Issues relating to communications were largely related to a lack of or poor formal communications between stakeholders. Largely it was identified that there was a gap between internalised knowledge and that expressly formulated and communicated.
Atkinson, AR 1999	The role of human error in construction defects	Empirical studies, a general survey and three house-building studies were undertaken. These studies utilised statistical analysis, observations and interviews to collect data. The survey used a questionnaire to query 107 construction professionals on defect factors.	Found that human error was a significant factor in defect creation. It also identified a strong bias in defect cause towards those attributed as 'managerial'. The interviews highlighted the significant distance which can occur between defect location and causes location, in terms of project structure.

Table 3.1: Analysis of papers on Defect Causes

To summarise the above, a matrix of all available research papers which have undertaken a review of apartment defect causes is included below.

	Defect Cause Matrix											
Causes	Josephson and Hammerlund (1999)	Atkinson (2002)	Porteous (1992)	Jingmond and Agren (2015)	Forcada et al. (2012)	Cromellin et al. (2021)	Chong, W & Low, SP (2006)	Karim, K, Marosszeky, M & Davis, S 2006	Johnston, N 2019	Aljassmi, H, Han, S & Davis, S 2016	Chong, WK & Low, SP (2005)	Jonsson, AZ & Gunnelin, RH 2019
Project environment	X											
Organisational culture										X		
Commercial Pressures									X			
Exposure (environmental)			X								X	
Design and Constructability							X					X
Material quality					X					X		
Motivation	X				X			X				
Management Strategy		X		X				X				
Workmanship								X		X	X	
Time Pressures		X			X				X			
Human error	X		X						X	X		
Information sharing					X	X		X				X
Poor Communication		X			X	X		X				X

Figure 3.1: Defect Cause Matrix

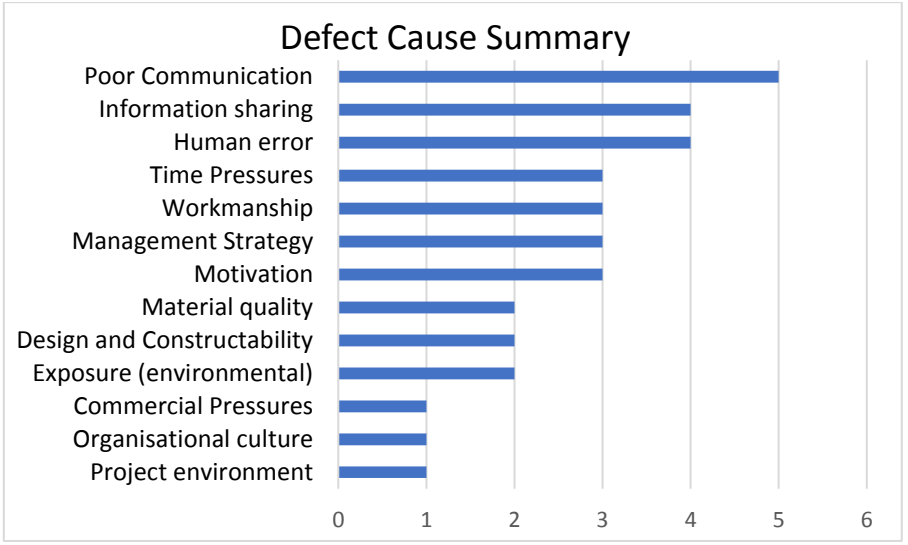


Figure 3.2: Defect Cause Summary

The summary of defect causes from the literature identified the primary causes of apartment defects as poor communication, information sharing and human error. The issue of information sharing and management in the industry has been largely covered within the literature review. These issues are also represented in poor communication, and both can be observed at all levels of a project – local, managerial or within the broader enrivonment within which the project is undertaken. Human error as a cause is primarily based on analysis done at the local level – directly where the defect physically manifests, however these can also occur within the project and company structure. Other common defect causes identified were time pressures, workmanship, management strategy and motivation. Time pressures are a factor of the apartment sector given the very high proportion built by developers for profit, and the very high levels of repeatability in work. Work is priced on small margins and time savings across large numbers of apartments can be the difference in a subcontractor making or losing money on a project. This issue accompanies that of workmanship, which can be impacted by these commercial pressures. The apartment boom has also strained the available skill and experience in the industry, and this is exacerbated by the limited oversight from the industry itself, regulators and eventual owners. In regard to motivation, the high volume of work and time pressures can lead to reduced motivations for project team members. The high demand for staff in the sector also allows staff with lower motivation or poorer workmanship to maintain work more readily or to change employers if required. While the above provides some insight into the common causes of defects, further research would assist in providing more detailed insight into the specific causes affecting the Australian apartment sector.

3.7 Defect Data Collection

In order to review defects it is first necessary to obtain access to relevant data. A number of sources were considered, and noting no single repository exists for the collection of apartment defect information. This information is stored in part between construction companies, body corporates, insurers, building inspectors, government agencies and others. In addition to this, access to information can be hindered by issues of privacy, commercial competition and perceptions of reputational damage for building owners and managers. The issues and limitations surrounding access to data were covered in greater depth in the literature review. Considering these limitations, access to defect information was therefore sought from all available avenues of the above, including prior research papers.

3.7.1 Methods of data collection

A number of data collection methods were reviewed in regard to their suitability to obtain additional defect data, including interviews, case studies, surveys, and observations. The primary need of data collection is to verify and reinforce any existing defect data obtained, to add veracity to the sample of defects reviewed. It was necessary to observe trends in data and as such a reasonable number of samples were required, ruling out methods such as case study. Additionally, the level of detail required was low – only requiring basic details of each defect including type, severity etc. Speed and ease of data collection was also considered, resulting in the selection of self-completion online questionnaire as the primary component of the data collection. The online questionnaire allows ease of access and submission and transfer of data back to the investigator, encouraging greater levels of participation. It also allows links to the questionnaire to be distributed easily, through a link or QR code, and the collation and extraction of data to promote ease of analysis.

3.7.2 Questionnaire Design

In order to a create an effective questionnaire there are a number of significant determinations that must be made, for example what information is being sought. It was determined that the information required is the types, frequency and severity of defects within apartments. A decision had been made to access data directly from apartment occupants, and the questionnaire also needed to consider that many respondents may not know how to determine the type of a defect, or perhaps what may even constitute one. The questionnaire design therefore provided significant guidance in regard to defect types and examples with each question to help guide participants. Additionally, the decision was made to allow free form responses for questions including defect type, which allows greater levels of description from the respondent. The responses can then be reviewed using a matrix of defect types from the literature to categorise the responses received.

The primary function of the questionnaire was to provide defect information, hence this section should form the majority of the content and information collected. Seven questions were asked for each reported defect, including a description, how the defect was identified, the severity, impacts of the defect, whether the defect has been rectified and if so the timeframe, and whether any actions had been undertaken regarding unrectified defects. The balance of questions allows sufficient insight whilst maintaining a focus on providing a short and focused questionnaire. A prompt is then provided for respondents to report additional defects, up to three total.

Careful selection also had to be made regarding the other questions to be asked as part of the questionnaire. The questions were to be as limited as possible to encourage participation and the

return of completed responses. Additional questions were focused on ensuring the suitability of the response, making sure the building was the correct height and age and that informed consent to participate was provided. Information was also collected on the reporting and responses to defects, as these also contribute to the prevalence and severity of these issues. Questions were therefore added to determine if the defect was reported and to whom, and whether the defect had been rectified and if so, what the timeframe was for rectification.

3.7.3 Questionnaire Distribution

The distribution of the survey needed to ensure the invitations reached the correct demographic and provided the highest likelihood of response. The literature review outlined the growth of apartments and the impact of this on the incidence in defects over the last 15-20 years. A decision was therefore made to look at buildings built after 2005, and in excess of 3 storeys. Data provided by the Australian Taxation Office (ATO) outlined that the majority of new apartments built in Australia during this period were centred in the three largest cities – Sydney, Melbourne and Brisbane (ABS, 2020). As this research was based in Brisbane and delivery of questionnaire invitations was required, the data collection was to be based in Brisbane. Data on apartment buildings meeting the construction date and height criteria were then sourced from the development map available from Brisbane Development (Brisbane Development Pty Ltd., 2022). The map is created collaboratively by a broad user base, and while not an exhaustive list of all developments in Brisbane it provided approximately 120 buildings meeting the criteria, totalling almost 16,000 apartments. The data had to be cleaned significantly to ensure accurate and consistent information regarding the type of development, height, number of apartments, completion year and other key information.

A sample size and selection method for the questionnaire then needed to be determined. A nonprobability sample was selected, as it limits the potential for selection bias and can improve the reliability of any findings (Bickman and Rog 2008, p. 78). A sampling frame was created using the development data, with each building within the sampling frame being allocated a number for selection. Simple random sampling was then used to create a list of buildings to be surveyed from the sampling frame. Random numbers were selected using the RAND function in Microsoft Excel, which utilises a linear congruent generator to create pseudorandom numbers. The sample size was determined using the guidance outlined by Dillman (2007). With a population size over 5,000 and a +/- sampling error of 10% a total sample size of 96 is desired. The online questionnaire therefore set a target to exceed 100 respondents.

3.8 Industry interviews

While the defect data collection will provide data in regards to observed defects, greater context from those involved in the construction and operation of mid and high-rise buildings would provide the insight necessary to assist in interpreting and evaluating the data collected. In order to obtain this insight, interviews were sought from a variety of industry sources. This was necessary as the journey of a building from initial concept to completion and operation involves a myriad of stakeholders – all of whom have the potential to influence the quality of the building.

The purpose of the interviews was to focus on the experiences and perspective of the interviewee on how defects were created, what were the causal factors, and what are the broader factors at play in the industry which have led to increasing defect numbers and a reduction in apartment quality over recent years. Questions were generated based on the themes and topics identified through the literature review. Allowance was also made for interviewees to raise topics not covered in the question, which allowed greater coverage of topics given the varying roles of interviewees.

3.9 Ethics

Data collection requires thoughtful consideration of ethical issues. While the selected topic can be considered low risk, it is necessary to consider all possible outcomes when conducting surveys and interviews and engaging with the public as required in the data collection phase of the project. Key to the collection of data was the condition of anonymity, and in collecting and storing only de-identified data. Information such as names, addresses and companies could create potential confidentiality and reputational risk for both public and professional participants, and as such these details will not be collected. In the context of the information required, this information also does not contribute to addressing the research question.

Consent forms for both the questionnaire and interviews were created to explicitly outline the purpose of the research and how information collected will be used, and to ensure participants understand their role and can therefore provide informed consent to participate. A decision was later made to incorporate consent for the questionnaire into the electronic format of the questionnaire to simplify the process and ensure informed consent was received prior to receipt of the submitted questionnaire. Information sheets for questionnaire and interview participants were also created, to provide a more detailed outline on the study and any potential privacy concerns, as well as providing project contact details. The information sheet is provided as a link, with shorter summary information

on the questionnaire itself, in order to not overwhelm potential participants with text and therefore encourage higher levels of participation.

Ethics approval for the project was obtained from the University of Southern Queensland Human Research and Ethics Committee. The approval demonstrates that the procedures and processes to be undertaken as part of the project work have been demonstrated to be safe and suitable for all participants. The work undertaken will also comply with the Australian Code for the Responsible Conduct of Research and USQ's Research Code of Conduct Policy. Details of the Research Ethics Application are included in Appendix B.

3.10 Risk Assessment

In order to properly evaluate risk to the project a risk assessment was undertaken using USQ's Online Risk Management System. The evaluation identified only risks associated as 'low' due to the nature of the work being primarily theoretical. Some access to construction sites may be required as part of the interview process, however again these risks are low when managed with appropriate controls. Details of the Risk Management Plan and the identifying details are included in Appendix C.

3.11 Resources

It will be necessary in order to meet the objectives set for the project to access and utilise a number of resources. As a primarily theory-based research project, key to establishing the history and learnings on the topic will be access to prior research. This need will be met through systems such as the USQ library service, and online research services such as Scopus, Science Direct and Google Scholar. Access to articles is expected to be available primarily through USQ access arrangements, however paid access may also be required.

Key to reviewing current defect trends within the Australian apartment construction sector will be access to data on defect type and frequency. A number of sources will be investigated for this including government agencies, building authorities, building inspection companies, strata management companies, construction companies and owners. It will be necessary when accessing data to use de-identified data and guarantee confidentiality. Existing industry contacts form the author will be utilised as required for data access or interview of industry personnel. While there is no expected cost for the access to this data, limitations to the availability, suitability and completeness of data is expected, and as such the methods and means of defect data access will remain flexible. The data collection will also require use of an online questionnaire and associated invitation to complete. The

invitation to complete will be professionally presented and printed at some moderate cost, in order to encourage participation and trust in the questionnaire.

Insight into the industry perspectives will also be sought as a data point for the project. This will require access to industry personnel in areas such as construction, management and maintenance of these building types. The method of data collection in all areas when dealing with industry will be carefully designed to minimise time burden on the participants to encourage greater participation.

Finally, the research report development will require office space and equipment. The needs summarily will be computer hardware and software, internet connection and printer. A summary of the resources required, their availability and costs are provided below.

Project Resource Requirements

Resource	Access	Cost	Importance	Alternative Available
Building Authority Data	Limited	Low ($0-$300)	Very High	Yes
Audit/defect Reports	Limited	Low ($0-$300)	Very High	Yes
Questionnaire participants	Limited	$0	Very High	Yes
Prior research	Available	Low ($0-$300)	Very High	Yes
Computer	Available	$0	Very High	Yes
Software (Ms Office, Endnote)	Available	$0	Very High	Yes
Printer (questionnaire invitations etc.)	Available	$100 consumables	High	Yes
Orthopaedic office chair	Procured	$70 (1-year depreciation)	High (see Risk Assessment)	Yes
Electric standing desk	Procured	$100 (1-year depreciation)	High (see Risk Assessment)	Yes

Table 3.2: Project resource requirements

3.12 Project Plan

A project plan denoting key timelines and project milestones has been developed in the form of a Gannt chart. The chart was developed during the initial phase of the project and has largely tracked on course. There has however been some rearrangement of tasks in order to accommodate changing

priorities, notably within this Data Collection phase of the plan. A copy of the updated project plan is included in Appendix D.

4 Results and Data Analysis

4.1 Introduction

The purpose of the data collection undertaken and supporting methodology is to determine the defects which are occurring within apartment building greater than 3 stories. This determination will be made principally from the feedback provided to the online questionnaire, providing quantitative data on defects. This data will be supplemented with analysis obtained from the interviews conducted with industry professionals, increasing the insight into the defect data. This method of analysis can be broadly described as explanatory sequential design, whereby the quantitative questionnaire data is analysed, then supplemented with analysis of the qualitative interview data in order to achieve the project objectives.

4.2 Questionnaire format

The method for obtaining respondents to the online questionnaire was broadly described in Section 3. An outline of the online questionnaire format and contents is included below:

Questionnaire Outline

Section #	Section Title	Questions
1	Overview and Informed Consent	Questionnaire Overview Informed Consent information
		Do you wish to participate?
2	Apartment Defect Questionnaire - Resident	Do you live in an apartment/unit in a building 4 stories or higher?
		Have you identified any defects in the property?
		Please provide the approximate age of the building, if known
3	Defect #1	Please select the type of defect
		How was the defect identified?
		Please describe the severity of the defect
		Select the impacts the defect has had on you and your occupation of the property
		Has the defect been fully rectified?
4	Rectified Defect #1	Approximately how long did the defect take to get rectified?
5	Unrectified Defect #1	Have you taken any action regarding the defect?
6	Reported Defect #1	Approximately how long ago was the defect reported?
		What prevented the defect being rectified?
7	Report Additional Defect?	Would you like to report an additional defect?

Table 4.1: Questionnaire Outline

*Sections 3-6 repeat 3 times if a 'Yes' response to the 'Report Additional Defect' question is selected. This allows reporting for up to 3 defects for each respondent. For clarity and simplicity of analysis the 3 rounds of defect data collection have been combined.

4.3 Questionnaire Results

4.3.1 Introduction and Informed consent

The landing page for the questionnaire outlined the basic information of the questionnaire, including the objectives the type of information to be collected and the purpose for this collection. The informed consent statement was also contained on this landing page, in order to meet the requirements of the USQ ethics approval. The analysis of the questionnaire results below is based on the 104 participants who opted into the questionnaire and agreed to participate after reading the informed consent.

4.3.2 Preliminary information

The function of the next section of the questionnaire was to ensure the participant met the criteria for the questionnaire. This required that they live in an apartment in a building greater than 3 stories, and that they had identified at least one defect in that property.

4.3.2.1 Do you live in an apartment building 4 stories or higher?

Provided as a yes or no question, to determine whether the respondent is reporting defects from an apartment in a mid-rise or high-rise building.

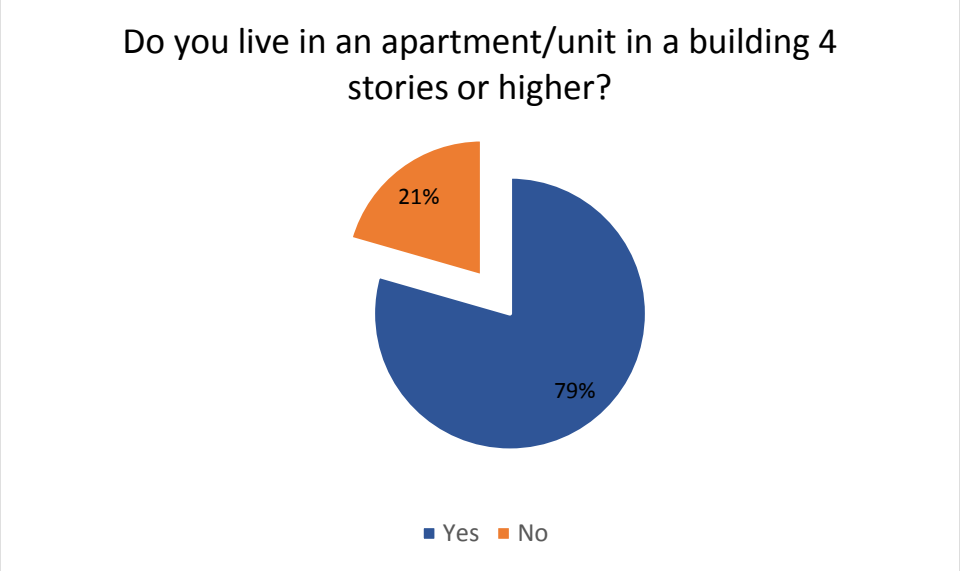


Figure 4.1: Do you live in an apartment/unit in a building 4 stories or higher?

82 of the 104 responses received (79%) stated that they lived in a building greater than 3 stories, in accordance with the focus of the study. It is noted that the questionnaire invitations were only delivered to properties meeting this criterion. It is possible the wording of the question could be interpreted as such that the height is in reference to the apartment location within the building, and not the building height itself. The questionnaire invitation was also displayed in some noticeboards in public spaces and as such a proportion of respondents may have not met the study criteria.

4.3.2.2 Have you identified any defects in the property?

Provided as a yes or no question, a 'No' response would thank the participant and end the questionnaire after page submission (Question 3). A 'Yes' response would allow the respondent to proceed to subsequent sections of the questionnaire.

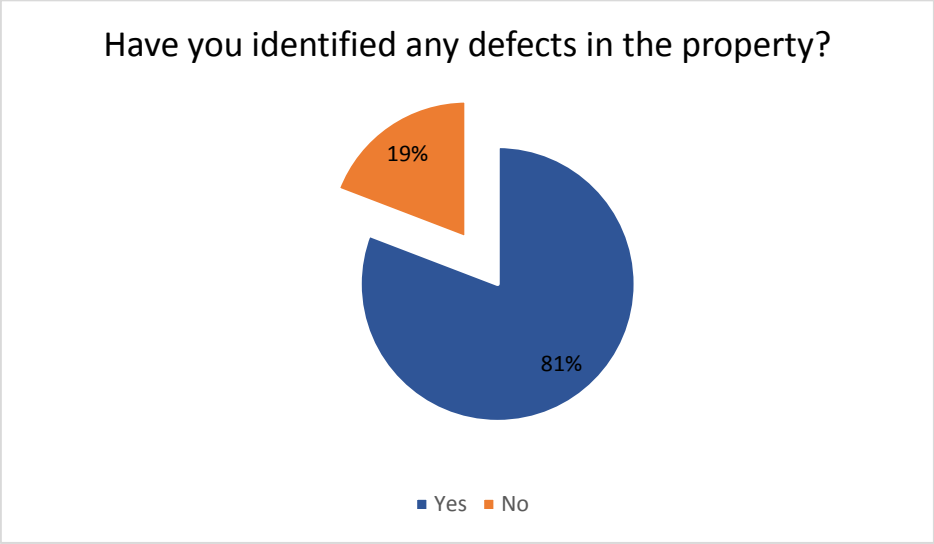


Figure 4.2: Have you identified any defects in the property?

84 of the 104 respondents (81%) noted that they had identified defects in the property. This rate of defect incidence reinforces the need for the study and provides sufficient data for the further stages of the questionnaire.

4.3.2.3 Please provide the approximate age of the building, if known

This question was broken down into 4 timeframes, with timeframes determined considering the majority of apartments in Australia have been constructed within the last 20 years. The intent of the question was to analyse whether apartments were more likely to have defects based on age, and if differing types of defects are more likely to affect properties of differing ages.

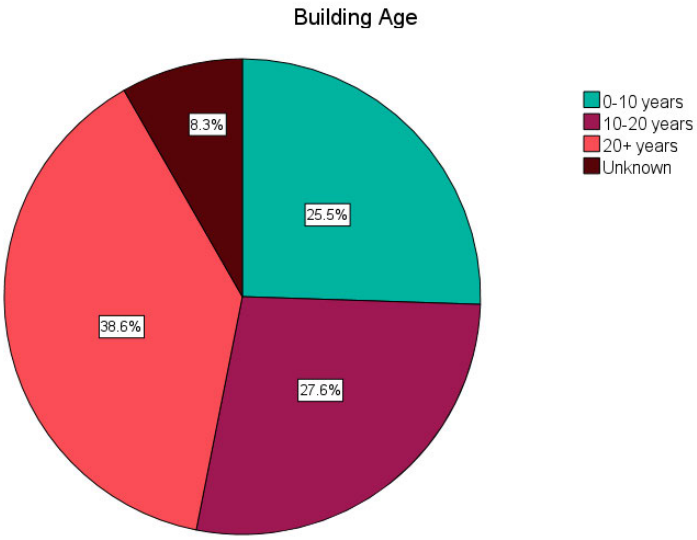


Figure 4.3: Building Age

A good mix of building ages were presented in the responses, allowing analysis to be undertaken between the defects identified for each building age. 38.6% of respondents lived in a building 20+ years of age, which represents those buildings constructed prior to the apartment boom in Australia. 27.6% lived in buildings 10-20 years of age and 25.5% lived in building 0-10 years of age, representing those built during the boom. 8.3% of respondents were unsure of their building age.

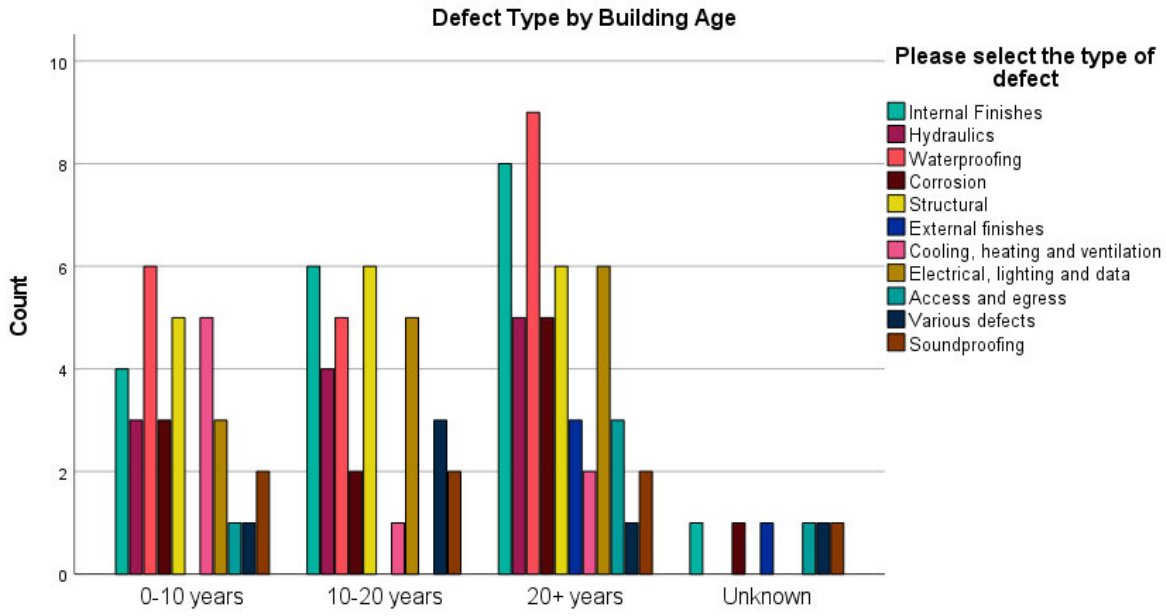


Figure 4.4: Defect Type by Building Age

Figure 4.4 shows a breakdown of each building age category along with the defect types by frequency. The variance in defect type by defect age is within reasonable expectations for most defect types. The

exception to this is Cooling, Heating and Ventilation system defects, which were much more common in newer building (0-10 years) at 15.9% than in older buildings - 10-20 years (2.9%) and 20+ years (4%).

4.3.3 Defects

The third questionnaire section collects information on the defects reported by the participant. The questionnaire requests defects to be reported in order of severity, with the section repeating to allow up to 3 defects to be reported. This was a functional requirement of the platform for the online questionnaire, and as such the results of all reported defects have been combined in this section to aid in the analysis.

4.3.3.1 Defect Types

This section was broken down into 7 key categories, based on research from the literature review and notably the study undertaken by Johnston & Reid (2019). By providing categories, data can be grouped more meaningfully into distinct building elements, improving the ease and clarity of analysis. Respondents also had the option to enter a custom defect type, to allow for categories outside these 7 main areas or where there was uncertainty as to which category to allocatea defect to. Examples of common defect types were provided for each defect category in order to simply the selection process and improve accuracy. Based on the information provided by respondents, 11 defect types were ultimately used to categorise the data.

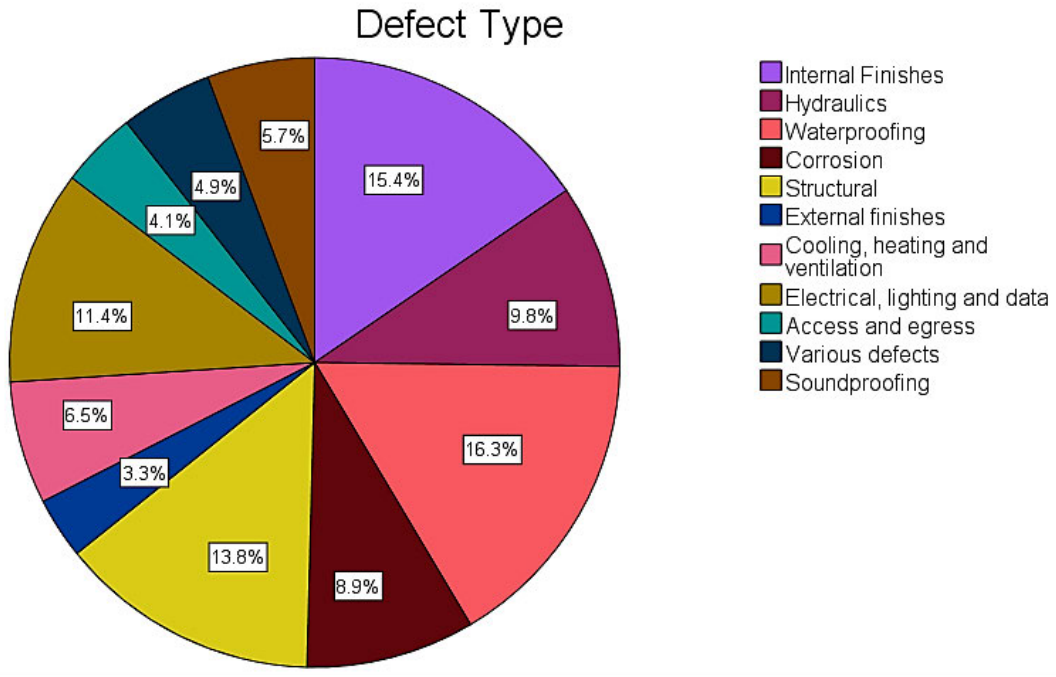


Figure 4.5: Defect type

The most frequent types of defects reported were Waterproofing (20 defects, 16.3%), Internal Finishes (19 defects, 15.4%) and Structural (17 defects, 13.8%). A full table of frequencies is provided below, detailing all 123 reported defects.

Defect Type - Frequencies

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Internal Finishes	19	12.9	15.4	15.4
	Hydraulics	12	8.2	9.8	25.2
	Waterproofing	20	13.6	16.3	41.5
	Corrosion	11	7.5	8.9	50.4
	Structural	17	11.6	13.8	64.2
	External finishes	4	2.7	3.3	67.5
	Cooling, heating and ventilation	8	5.4	6.5	74.0
	Electrical, lighting and data	14	9.5	11.4	85.4
	Access and egress	5	3.4	4.1	89.4
	Various defects	6	4.1	4.9	94.3
	Soundproofing	7	4.8	5.7	100.0
	Total	123	83.7	100.0	
Missing	System	24	16.3		
Total		147	100.0		

Table 4.2: Defect Type – Frequencies

Based on the frequency analysis, defects relating the Electrical, Lighting and Data (11.4%), Hydraulics (9.8%) and Corrosion (8.9%) were also commonly reported and together create a second tier of defect types requiring additional analysis. The frequency analysis will be used in conjunction with the severity analysis to detail the typical expected risk from each defect category.

4.3.3.2 Defect Severity

While the frequency tables showed the types of defects most commonly reported, it is necessary in order to prioritise future quality assurance and defect prevention works to rank each defect in terms of total risk. A multiple-choice question was provided to assign a severity to each reported defect. Five categories of severity were provided. The severity reported with each defect type is shown in Figure 4.6 below:

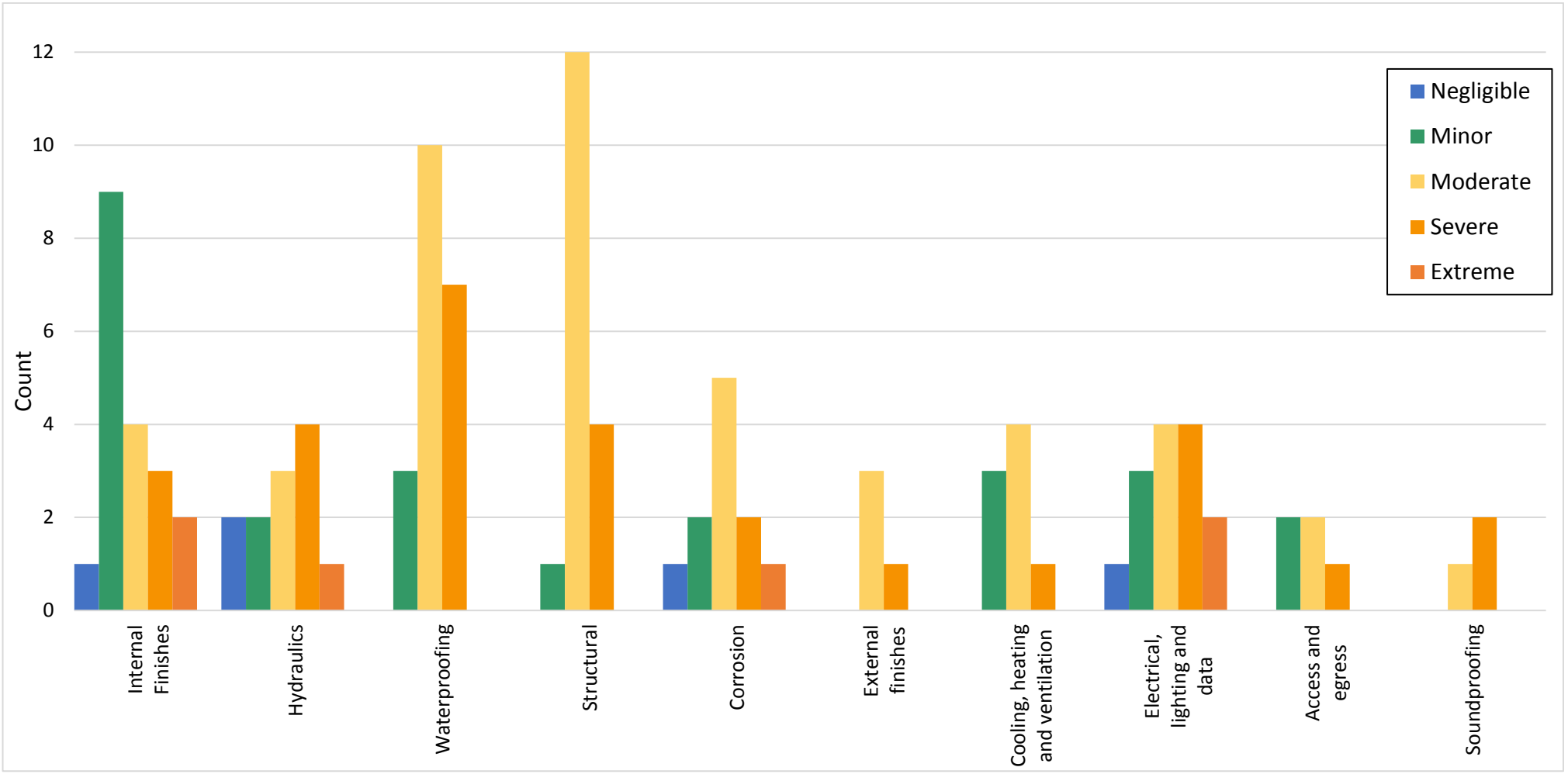


Figure 4.6: Defect Types with Severity by Count

Common defect types of Waterproofing and Structural showed a high proportion of defects identified as moderate or severe, with 85% and 84.1% respectively. It is therefore anticipated that with both high frequency and severity these will become target areas in the conclusions and summary of this report. Internal finishes, while frequently observed do not have a high severity, with 52.6% of defects reported as negligible or minor. Of the second tier of frequent defects identified in the frequency analysis, the average severity was moderate for Electrical, Lighting and Data and Corrosion, and a just below moderate average severity for Hydraulics defects. Further analysis of the overall risk rating for each defect type is undertaken in section 4.3.6.

4.3.3.3 How was the defect identified?

The question seeks to determine how defects are typically identified. The method of identifying the defect will feed into further analysis as to what actions were taken and whether the defect has been rectified. It also demonstrates the typical reporting method for defects, which can inform future analysis into the lifecycle of defects from identification to rectification.

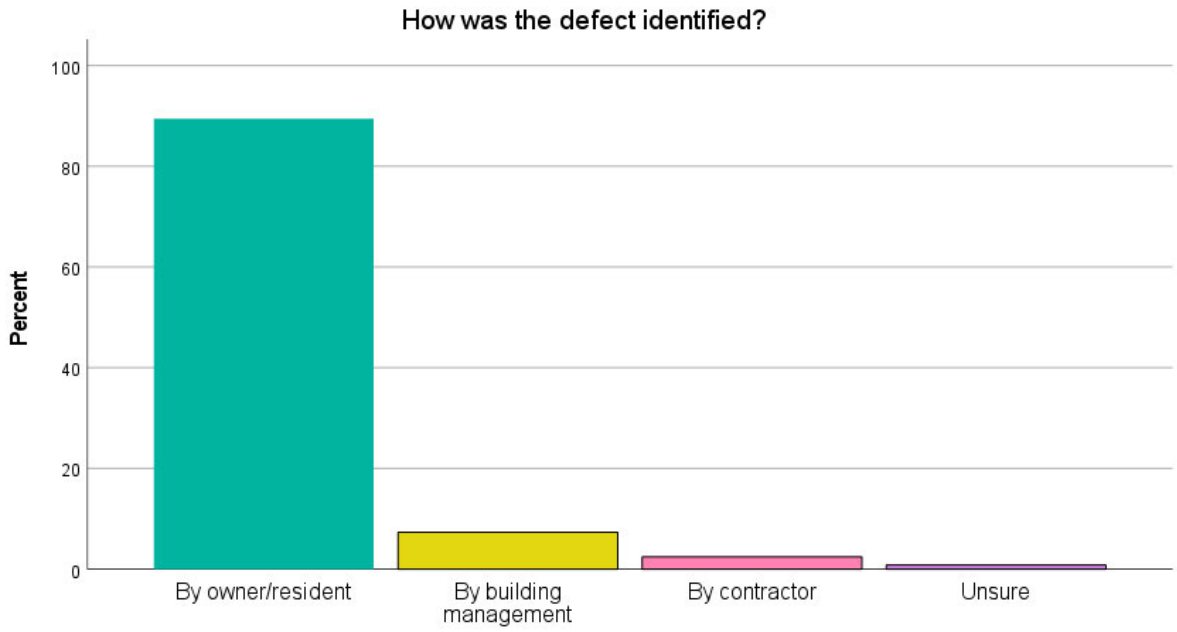


Figure 4.7: How was the defect identified?

As can be seen in Figure 4.7, the overwhelming majority of defects known to residents (110 of the total 123 reported, or 89.4%) were reported by the apartment owner or resident. While it is logical that residents and owners are more aware of defects they have reported, this does not negate that building committees should be proactively undertaking inspections in building and common areas and reporting these findings.

4.3.3.4 Impacts the defect has had on you and your occupation of the property

This question focused on the categories of impact the defect has had on the occupant, noting that defects can have psychological impacts in addition to cost and property use impacts. Opportunity was also provided for free-form responses to describe other impact types. The purpose of the question was to ascertain how the occupant viewed the way in which the presence of the defect and its associated impacts had affected them. Multiple selections were permitted, and the majority of respondents noted two types of impacts, as shown in Table 4.3.

Defect Impacts - Frequencies

		Responses		
		N	Percent	Percent of Cases
Type of impacts the defect has had	Cost impacts	44	29.3%	53.0%
	Property Use Impacts	50	33.3%	60.2%
	Psychological Impacts	50	33.3%	60.2%
	Health and Safety Impacts	5	3.3%	6.0%
	Time Impacts	1	0.7%	1.2%
Total		150	100.0%	180.7%

Table 4.3: Defect Impacts - Frequencies

The most frequently reported impact types were property use and psychological, with 50 respondents each. Cost impacts were also reported by 44 respondents. A deeper review into the subtypes of each impact and magnitude would be of benefit and should be considered as an area of future research.

4.3.3.5 Has the defect been fully rectified?

The question of whether the defect had been fully rectified will have implications in regard to the severity and impacts as described by the occupant. It also splits the questionnaire into two streams based on the response – to find out why the defect has not been rectified or to determine the timeframe within which the rectification works were completed. The purpose of the question was to facilitate the subsequent questions but also to ascertain more broadly what proportion of defects were being rectified fully.

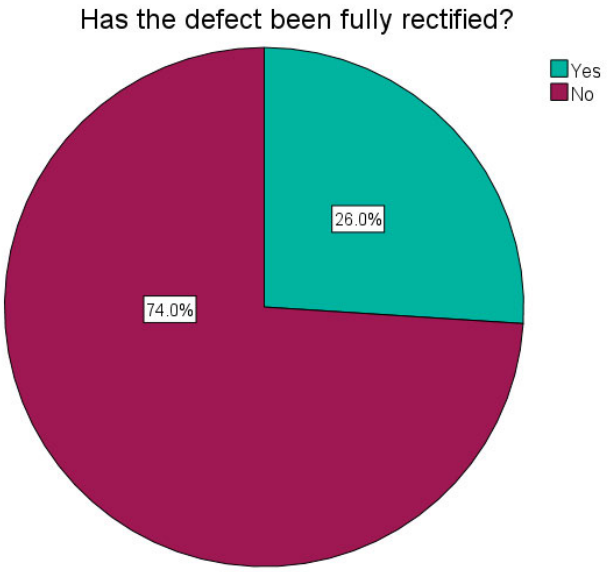


Figure 4.8: Has the defect been fully rectified?

The response to the question noted that 74% (91 of the 123) of the reported defects had not been fully rectified. This volume of unrectified defects would provide opportunity to collect data on what the respondents noted had been the barrier or issues preventing the rectification, and this information is discussed in section 4.3.5.

4.3.4 Rectification Timeframe

If the defect has been rectified as identified in the previous section, the respondent is asked to provide the timeframe for the rectification works. The timeframes are broken down into 5 categories from within 1 week through to greater than 1 year. The purpose of this question is to review the typical rectification timeframes for defects, and to analyse whether there are notable variances in this timeframe for different defect categories.

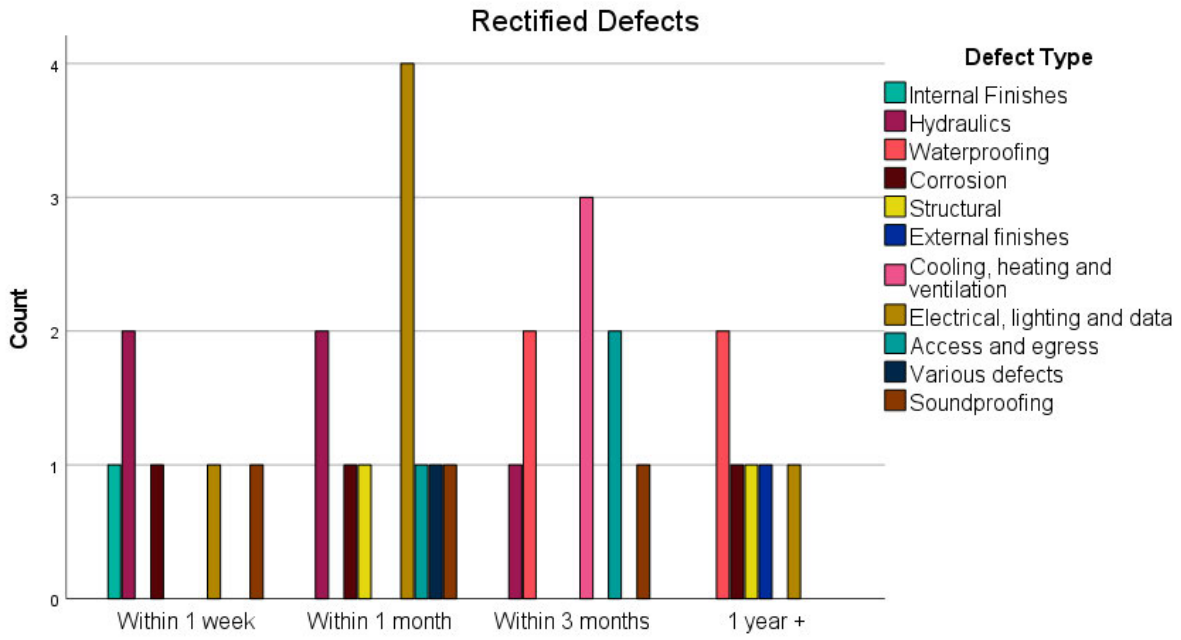


Figure 4.9: Rectified Defects - By Defect Type and Timeframe

The results highlight that Electrical, Lighting and Data and Hydraulics were typically dealt with quickly if rectified, with this occurring within 1 month. Issues relating to Waterproofing and Cooling, Heating and Ventilation however typically took greater than 3 months for the rectification works to be completed. This can likely be attributed the nature of these defects, with electrical and hydraulic issues often confined to a single apartment or issue location and thus being readily identified and repaired with clear responsibilities. Waterproofing and Cooling, Heating and Ventilation can more frequently relate to issues outside of the apartment reporting the issue, where increase complexity and issues determining responsibility and costs can delay repair works.

4.3.5 Unrectified Defects

Following from Section 4.3.3.5 whereby respondents were asked if the defect had been rectified, a 'No' response takes the participants through the below questions which provide more insight into what may have prevented the defect being repaired.

4.3.5.1 Have you taken any action regarding the defect?

This question sought to determine what, if anything, had been done once the defect had been identified. Options were given that the defect had been reported to either building management or real estate agent, that an attempt had been made to rectify the defect, or that no action had been taken. A freeform response was also provided however no participants gave alternative responses to

the question. The question aimed to determine what the typical course of action was for an apartment occupant upon discovery of a defect.

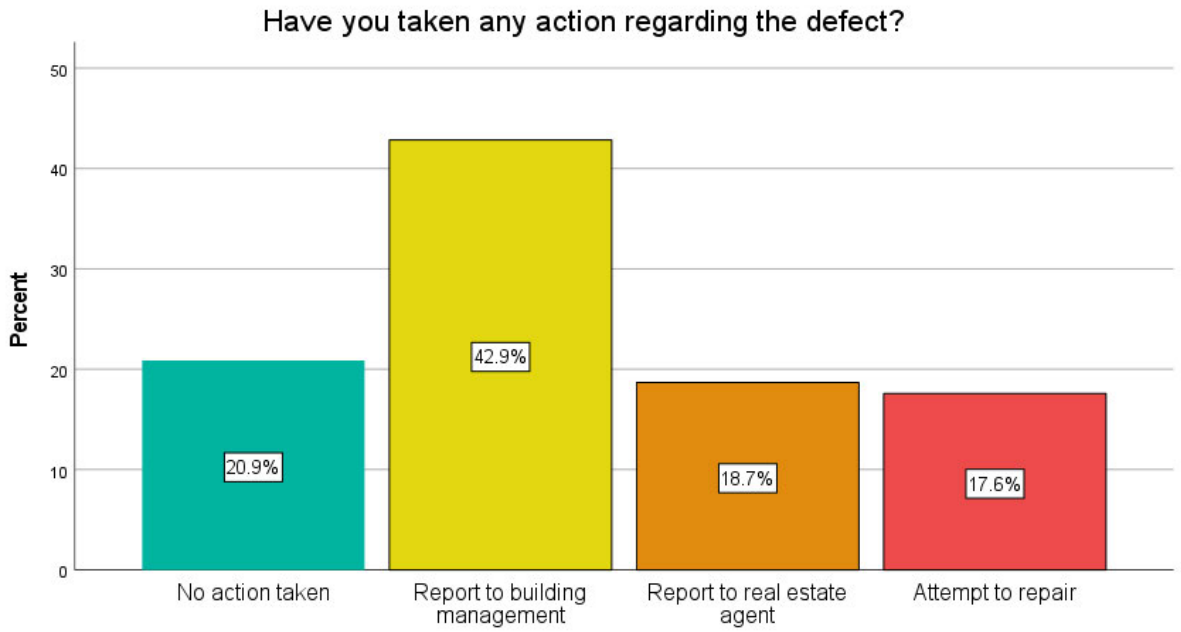


Figure 4.10: Have you taken any action regarding the defect?

The majority of responses had reported the defect, with 42.9% reporting to building management and 18.7% reporting to their real estate agent. Unusually 20.9% had not taken any action regarding the defect, and this may be related to defects with insignificant or minor severity. Finally, 17.6% had attempted to repair the defect.

4.3.5.2 Approximately how long ago was the defect reported?

The sum of the reported defects from the previous questions (38 responses) were then asked how long ago the defect had been reported. A number of timeframe options were provided ranging from less than 1 week to greater than 3 months. As this question section relates to unrectified defects, observations can be made on the length of time they remain unactioned after being reported.

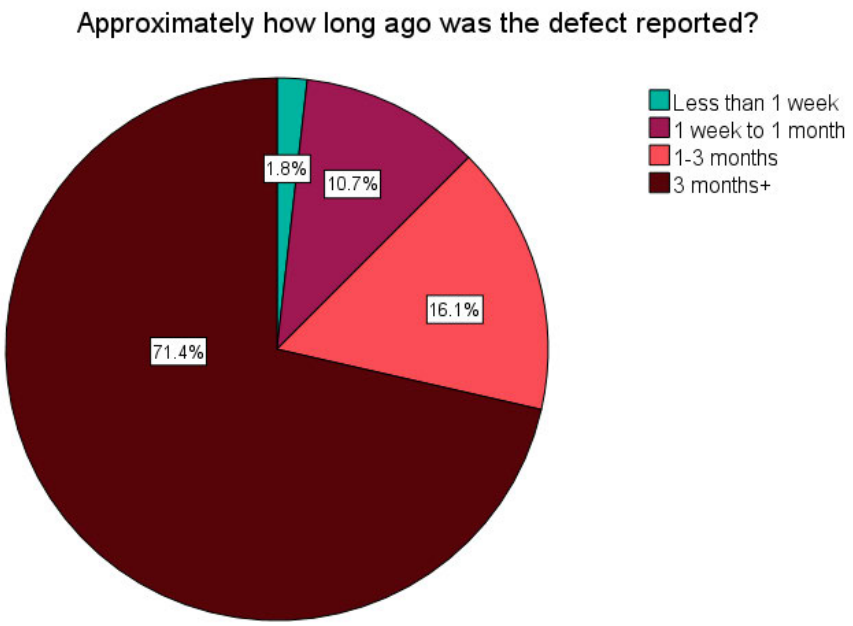


Figure 4.11: Approximately how long ago was the defect reported?

The responses showed 71.4% had reported the defect greater than 3 months prior, and this highlights that potentially greater detail could have been sought longer timeframes, for example greater than 6 months and greater than 12 months. To provide additional insight a crosstabs analysis was also undertaken with how long the defect had been reported against its severity. The purpose was to see the typical severity for the defects not rectified for greater than 3 months.

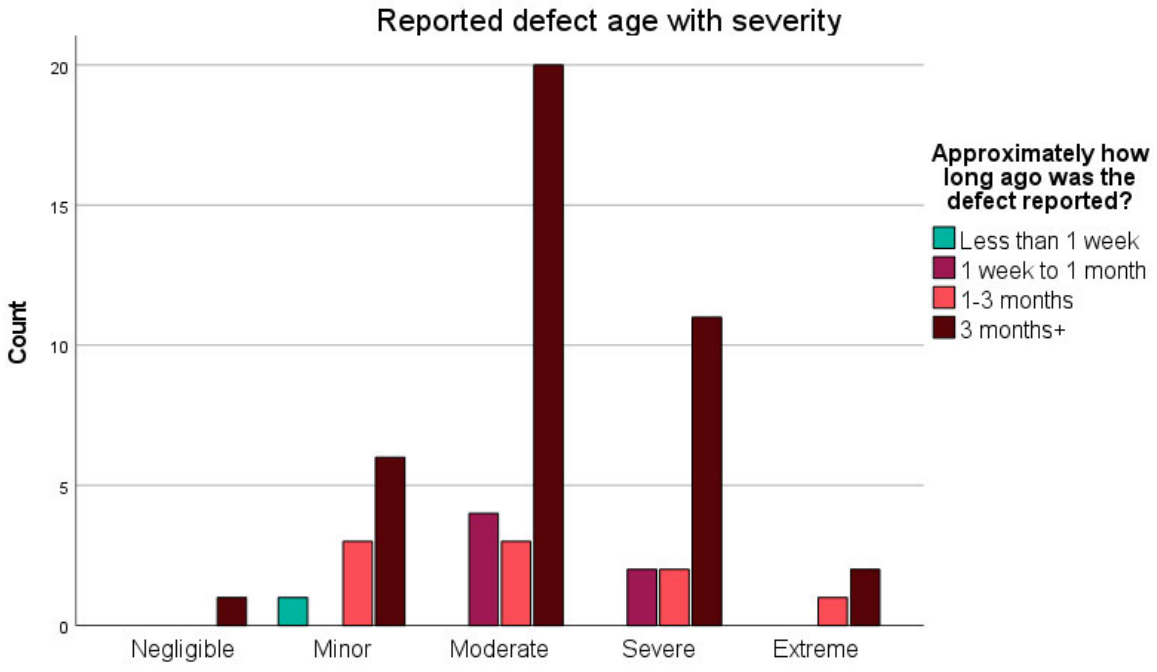


Figure 4.12: Reported defect age with severity

As shown above, the majority of defects reported greater than 3 months ago were considered moderate or severe. This highlights that it is not simply negligible or minor issues that remain unactioned for lengthy periods, and impacts to residents will be exacerbated significantly with long delays in rectification of these issues.

4.3.5.3 What prevented the defect from being rectified?

Respondents who noted their defect had not been rectified were also asked to consider the reasons behind that inaction. A number of potential causes were provided and the results provided in Figure 4.13 below.

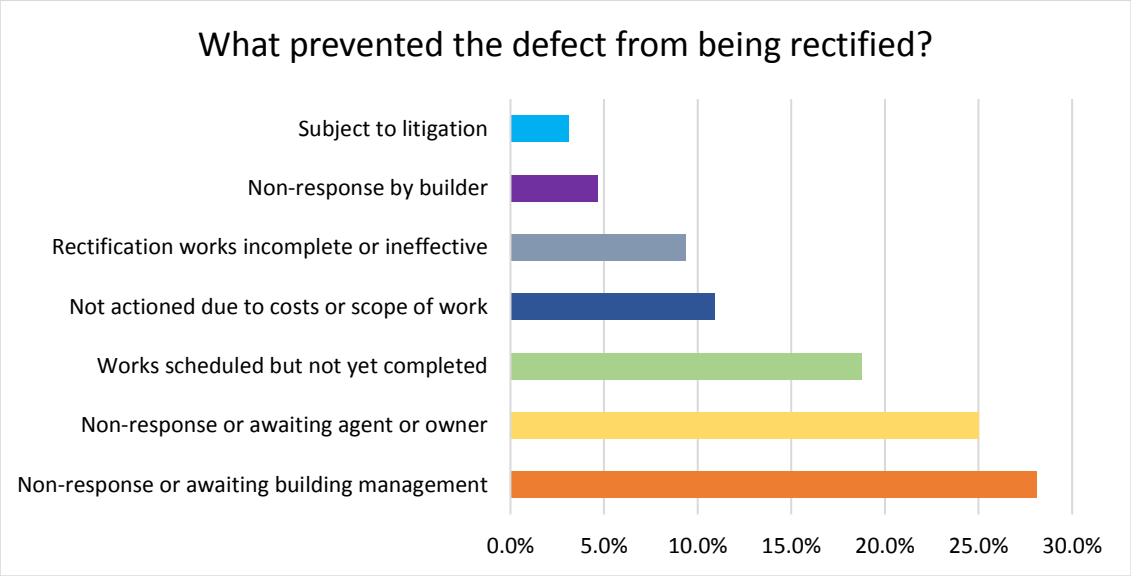


Figure 4.13: What prevented the defect from being rectified

The majority of responses highlighted that a lack of response prevented the defect being rectified, with 28.1% noting building management and 25% noting the property owner or agent as the party not responding. 18.8% noted works had been scheduled and not completed, and these could be considered as defects that will be rectified. Works that had been refused due to costs or scope comprised 10.9% of the response, and future work could look more deeply into the types of issues where parties refuse to rectify. Lastly, 9.4% noted that an attempt had been made to repair, but the repair had been ineffective.

4.3.6 Risk Rating of Defects

In order to meet the project objectives of identifying key building areas and defect types that require additional focus and quality assurance activities, it is necessary to score and summarise the overall risk presented by each defect type. In order to do this, a scoring system was created guided by risk management principles, whereby the likelihood and severity of the risk are multiplied to provide an overall risk score. Frequency scores utilised the reported percentage of defects for each defect type from the questionnaire. Severity information was also collected for each defect, ranking from negligible through to extreme. These severities were each assigned a rank as outlined in Table 4.4 below:

Risk	Negligible	Minor	Moderate	Severe	Extreme
Score	1	3	5	7	9

Table 4.4: Defect Risk Ratings

The total risk score for each construction system was then calculated using the following formula:
Total construction system risk = Average of all defect risk scores for that system, whereby
Defect Risk Score = Likelihood x Severity

Total Defect Risk Scores

Defect Type	Severity Score	Likelihood Score	Total Risk Score
Internal Finishes	2.1	16.25	33.75
Hydraulics	3.8	10	37.5
Waterproofing	3.4	25	85
Structural	3.4	21.25	71.25
External finishes	4.0	2.5	10
Cooling, heating and ventilation	2.5	10	25
Electrical, lighting and data	4.0	7.5	30
Access and egress	2.6	6.25	16.25
Soundproofing	4.3	3.75	16.25

Table 4.5: Total Defect Risk Scores

The above risk rating system highlights two main tiers of defects requiring a targeted focus in order to reduce defect impacts. The primary tier consists of Waterproofing (85) and Structural (71.25), which ranked significantly beyond all other defect types considering their high frequency and moderate to high average severity. The second focus tier consists of Hydraulics (37.5), Internal Finishes (33.75) and Electrical, Lighting and Data (30). The risk scores and tiers of focus defects are shown in Figure 4.14.

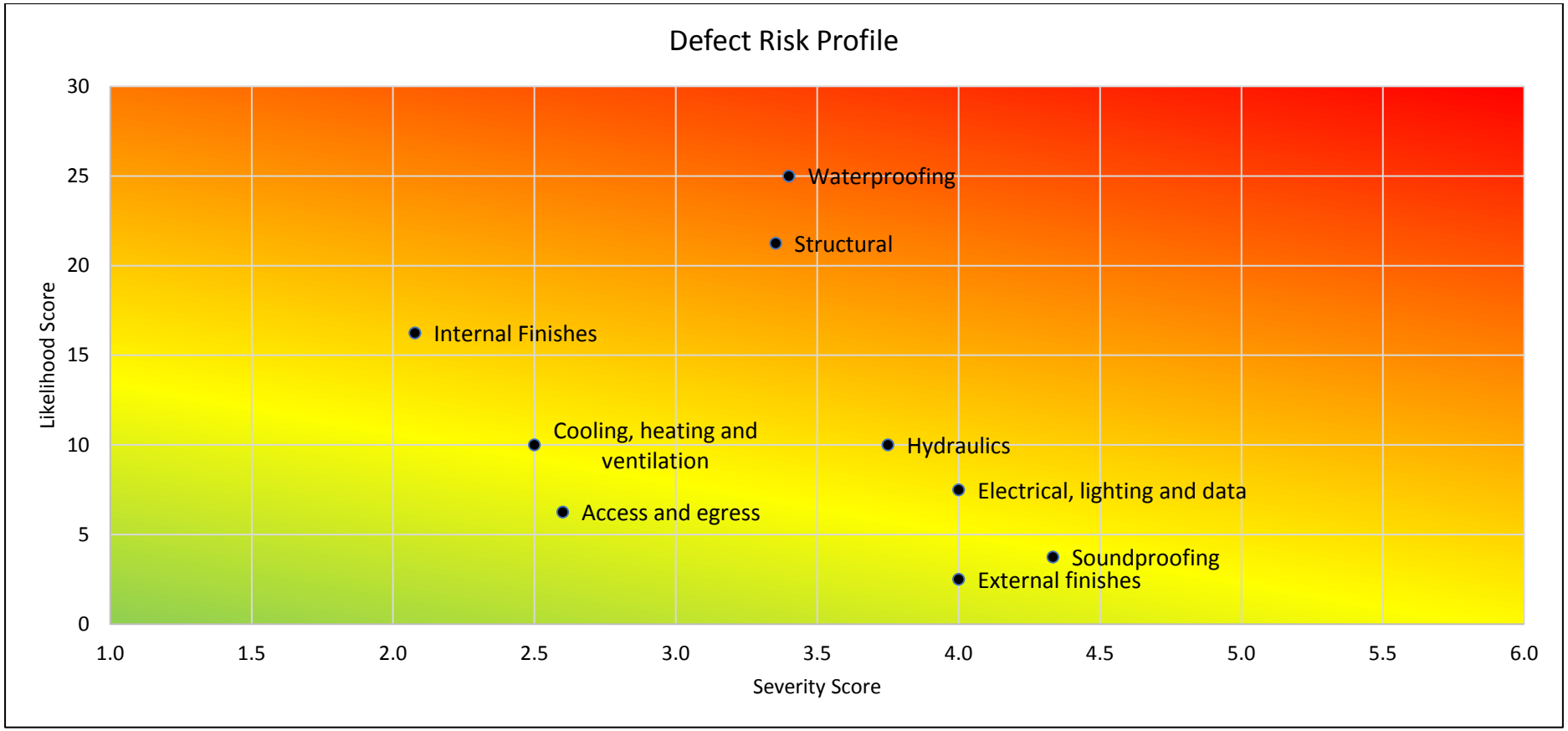


Figure 4.14: Defect Risk Profile

In order to determine the significance of the defect score, Z-scores were calculated for the defect risk scores. The Z-score is used to demonstrate the relationship of the defect risk score to the mean of all defects surveyed. From the analysis, waterproofing defects were 1.9 standard deviations above the mean and structural defects were 1.37 standard deviations above the mean. These were significant outliers in consideration of all defects studied, and this reinforces the need for a large portion of future research focus on these defect types. The full outline of defect type Z-scores is included in Figure 4.15 below.

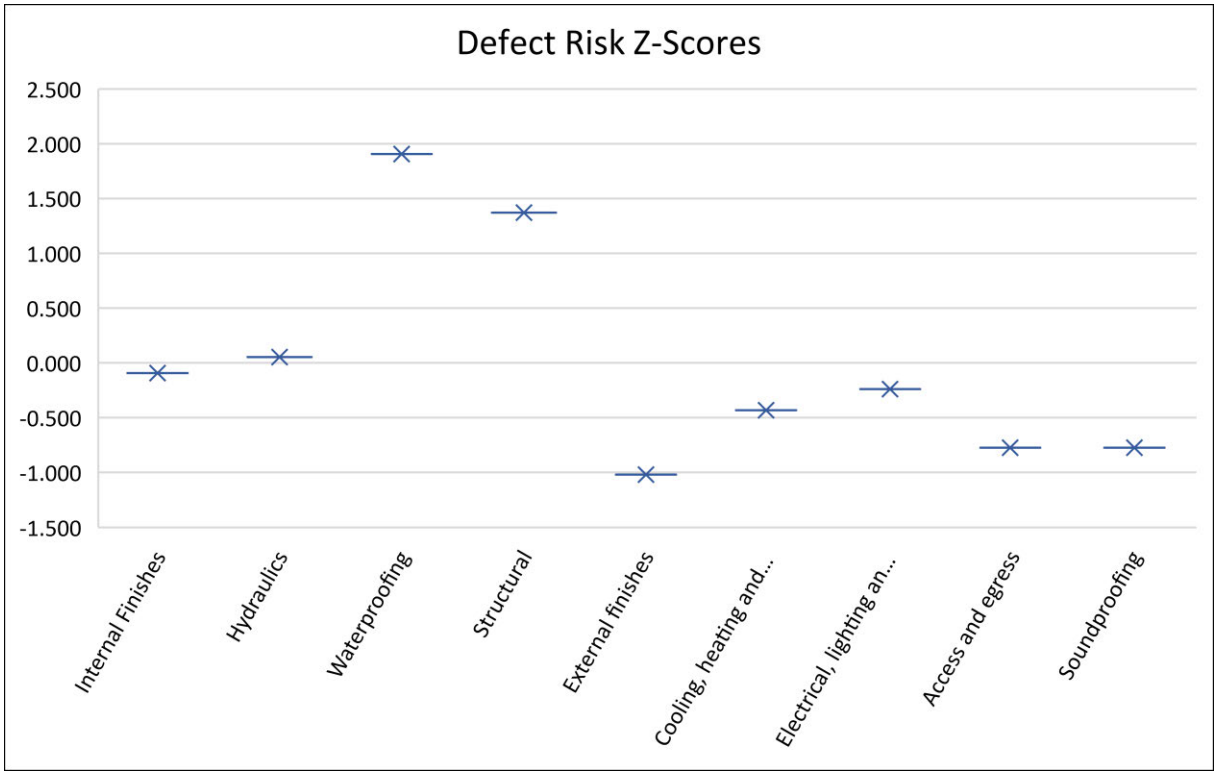


Figure 4.15: Defect Risk Z-Scores

4.3.7 Summary

The questionnaire provided a good insight into the types of defects occurring in apartment buildings and many of the associated activities relating to reporting and rectifying them. The analysis of the results are summarised below, focusing on key data findings that support the project aims.

Firstly, the reported defect rate from respondents of 81% is in accordance with previous research undertaken by Johnston & Reid (2019) who identified a defect rate of 85% and Easthope (2012) who reported a defect rate of 72%. This helps build confidence in the representative nature of the responses and also highlights the significant volumes of apartments affected by defects. In regard to building age, a good mix of building ages were represented from both pre and post the apartment building boom from around 2009. Little correlation was found between apartment age and defect type, with the most common defect types waterproofing and structural being frequently observed in buildings of all ages. The exception to this was electrical, lighting and data defects which were a much larger proportion of the defects observed in buildings 0-10 years in age.

The analysis of defect types and frequencies found that defects relating to waterproofing, internal finishes and structural were the most common types reported. The results relating to waterproofing and structural defects have a strong correlation to previous research undertaken by the NSW State

Government & Strata Community Association NSW (2021), which found most common defect frequencies of Waterproofing (34%), fire safety (20%), Structural (14%). Review of the severity of defects found that the overwhelming majority of waterproofing and structural defects were identified as moderate or severe, which combined with their high frequency identifies these as very noteworthy categories of defects when considering their total risk to apartment occupants.

The next sections of the questionnaire focused on how defects were reported, handled and rectified. The most common method for identifying and reporting defects was from the apartments occupants, representing 89.4% of all reported defects. As residents should also be aware of defects within their building through their building management committee, this showed the limitations of inspections and committee activities in identifying defects. In regard to impacts these issues are having on building occupants, the most common impact types were psychological and property use, with most respondents identifying more than one impact type.

In regards to defect rectification, 74% of respondents noted that their defect had not been fully rectified. While this highlights issues in addressing these issues for residents, it is unclear without the context of the how long the defect has bene present and its severity at to whether the lack of rectification would be considered reasonable. It also provided opportunity for a good volume of data to be collected in regards to the unrectified defects – particularly in regard to what may be preventing rectification.

The results found most defect that had been rectfieid were completed within 3 months. Electrical and hydraulic issues were typically dealt with in less than 1 month, as these likely significantly impact apartment usability (i.e. taps, lights etc.) and could be low cost and straightforward, isolated to individual apartments. More complex defects that may also involve multiple apartments and higher costs such as waterproofing and heating, cooling and ventilation typically took over 3 months.

An analysis of unrectified defects found that 61.6% had been reported to either building management or real estate agents, 20.9% had no action taken and 17.6% of respondents had attempted to rectify the defect. Of these reported defects which comprise the majority of those unrectified, 71.4% had reported greater than 3 months earlier, showing a significant lag in the response and follow up to reported defects. In addition to this, analysis of the severity of these defects reported for greater than 3 months showed 33 out of 40 (82.5%) were moderate, sever or extreme. Higher severity defects with high rectification timeframes present significant impacts to residents, and the delay causes and

impacts would be an area that would benefit from future research. Data collected on the perceived impediments to defect rectification that 53.1% were stalled by a lack of response from either building management or the real estate agent or owner. Schedule works comprised 18.8% of responses and these require no additional review. Works refused due to costs of scope were 10.9% and lastly works where repair had been attempted but not effective were 9.4%. Works that had been refused due to costs or scope comprised 10.9% of the response, and future work could look more deeply into the types of issues where parties refuse to rectify. Lastly, 9.4% noted that an attempt had been made to repair, but the repair had been ineffective.

Finally, the risk rating system highlighted two main tiers of defects requiring a targeted focus in order to reduce defect impacts. The primary tier consisted of Waterproofing (85) and Structural (71.25), which ranked significantly beyond all other defect types considering their high frequency and moderate to high average severity. The second focus tier consists of Hydraulics (37.5), Internal Finishes (33.75) and Electrical, Lighting and Data (30). The Z-score analysis showed waterproofing defects were 1.9 standard deviations above the mean and structural defects were 1.37 standard deviations above the mean. These were significant outliers in consideration of all defects studied, and these should therefore be the primary focus of defect prevention activities and future research.

4.4 Interviews

As outlined in the project methodology, the data collection phase of the project utilises a mixed method of collection. This involves the online questionnaire – detailed in the previous section, which provides the quantitative data to outline key statitstics regarding defects. The second method – described in this section, provides additional insight into the industry and qualitative data trends through interviews undertaken with a number of industry experts. The experts were selected due to their involvement and knowledge regarding the design and construction of apartment buildings, to impart knowledge on potential issues and factors which may lead to the creation of defects from theses phases of a building lifecycle.

The interviews were limited in structure, which the questions and prompts selected being informed largely by information gathered from the literature review and supplemented with findings from the initial results of the online questionnaire. The overall intent of the questions is to prompt the interviewee to detail their thoughts and experiences with regards to the occurrence of defects in residential apartment buildings. Specifically the questions were to obtain from the interviewees what they perceive to be contributing to the overall reduction of quality in residential apartment buildings.

All participants selected have direct experience in either the design, construction or handover of these building types, with a requirement of at least 5 years experience in these specific areas.

The interviews were conducted through a combination of remote methods including phone and through video conferencing platforms Mcrisoft Teams and Zoom. The use of these methods minimised issues relating to timing of interviews, travel related issues and protocols surrounding access to construction sites. The typical interview timeframe was between 20 and 40 minutes, depending on the available time of the interviewee and the depth of response to questions they were willing to provide. The questions were to simply act as prompts and a rough guide where required, respondents were allowed to deviate and explore own topics and themes as desired.

Industry Expert Interview Questions

Question	
1	Do you believe that there is a major issues in regards to quality issues and defects in residential apartments?
2	What is your involvement in the development of these buildings?
3	What are the issues you are involved in or aware of that you believe contribute to the creation of defects?
4	What other factors influence the creation of defects?
5	What impact do defects have on your company?
6	What could be done to reduce the frequency or severity of defects observed?

Table 4.6: Industry Expert Interview Questions

4.4.1 Results

The below section summarises the key comments and insights provided by the experts interviewed. Their position is noted alongside the phase of the project lifecycle they are typically involved in.

Interviewee 1 – Engineer (Design Phase)

- Agreed that there is a major issue surrounding quality issues and defects in the industry
- Often much of the blame surrounding the occurrence of defects and quality issues is directed at private certifier, and they believed that this blame was misdirected.
- These buildings types are immensely complex and this means the certifier cannot be expected to oversee all elements with the required level of knowledge.

- The certifiers I have worked with have largely been very risk averse and utilising a very conservative view of building standards and codes.
- Most of my work has been in Queensland and we are fortunate that we have more stringent regulations than in other states.
- Issues contributing to poor quality outcomes can be observed at all levels through projects
- Since the early 2000s a growing shift in the industry has been to procure buildings through Design and Construct (D&C) contracts.
- Tendering of these building is done using the bare minimum of design documents, seeking contractors to complete the design and construct the building. These contractors are tendering at fixed prices and completing the design during the construction phase of the project, leading to discrepencies, oversights and other issues.
- There is also an issue of lack of oversight as the design which in the past would have been completed by a separate team of architects and engineers who oversaw the construction to their design is now done by the contractor, so the design anomalies and shortcuts are not brought up or rectified.
- One means of addressing the issues above is a return to these more traditional forms of building procurement, whereby a separate design team is engaged to fully complete a high quality design, and to oversee its implementation.

Interviewee 2 – Estimator (Tendering Phase)

- Agreed that there is a major issue surrounding quality issues and defects in the industry
- Almost all of projects we tender on now are for design and construct (D&C) contracts, and this has been a major contributor to quality issues in my opinion.
- The push to the D&C method has been a shift towards the lowest standards in terms of design and quality.
- Much of the design and associated risk is now in the hands of the contractor, and this has led to lower quality work done quickly and with overworked and inexperienced teams.
- An increasing proportion of this work is done by graduates and those with very little practical experience.
- There is little appreciation from clients that quality works takes a bit more time and costs a little more, and these will save money in the long term for responsible developers.
- Projects are tendered on very slim margins and this does not allow for or encourage the right attitudes and instead promotes a view that corners must be cut to maintain profits.

- The lack of oversight in the industry adds to the above issues, when your work isn't checked and the incentives to cut corners are high poor outcomes are inevitable.

Interviewee 3 – Consulting Engineeer (Various Phases)

- Agreed that there is a major issue surrounding quality issues and defects in the industry
- My experience has been as a consulting engineer working in various stages primarily in the design of residential apartment buildings. This time has been split between contractors from Tier 1 to Tier 3 on major projects, and it is a vastly differing experience across these levels.
- The Tier 1 contractors are much more considerate of whole of life costs and reputational costs.
- In regard to Tier 2 and 3 contractors, the quality systems and practices are much more hit and miss. It is much more important at this level to seek out a specific company based on their reputation.
- Little is known by the public about the company that will be building their home or investment, consumer power would be a powerful incentive in encouraging good developer behaviours.
- During my time in the industry (20+ years) there has been continuing downward pressure on prices for consulting engineers, which has been driven by increasing numbers of smaller companies and those relying on graduate or overseas offshoring to reduce costs.
- The quality of documentation produced has also gone down over this period due to the reduced expertise and time spent on each project.

Interviewee 4 – Engineer (Design and Construction Phase)

- Agreed that there is a major issue surrounding quality issues and defects in the industry
- I have spent almost 2 decades working with a Tier 1 builder, across a wide variety of projects and locations
- During this time I have observed that an increasing reliance on Design and Construct (D&C) contracts has allowed contractors to deviate from design documentation which in itself has become a growing concern.
- The issue as I see it is that little is made or known to the general public of the reputation of the builder of their apartment. This is especially pertinent when smaller contractors are involved, as there is often little reputation to protect.
- The bigger players have the resourcing and systems which support proper quality management

- They also have more concern over reputation and wish to keep operating in markets for long periods, so maintaining this business and obtaining repeat customers is a goal.
- I do see a lot of blame being directed at certifiers, and I think this is an easy thing to do for developers to defer and deflect blame towards them.
- I do not agree with a lot of the narrative around not buying apartments built in the last 20 odd years.

Interviewee 5 – Consulting Engineer (Design Phase)

- Agreed that there is a major issue surrounding quality issues and defects in the industry
- There has been demonstrated issues with poor quality, non-conforming products used in the industry i.e. flammable cladding and this has primarily been in my opinion due to a failure in regulation at the various levels of government.
- I have observed these product compliance issues in other building components also.
- The elements of a building are now typically packaged into a variety of subcontractor packages. Largely these subcontractors are relied upon to undertake their own quality assurance and certification of work, with the certifier merely collecting the various certificates.
- The above issue is often put onto private certifiers however it is not possible for them to inspect all the works first hand. They also cannot be expected to be expert in all elements of what are often very complex buildings.
- Obviously as these works packages for subcontractors are typically fixed price theres an incentive for some of the less scrupulous subcontractors to push the areas of short cuts with lower quality work and materials.
- All facets of the industry needs increased oversight. Material compliance issues took major fires in order to get the necessary review and now this attention needs to be directed at the broader quality issues in these apartments.

Interviewee 6 – Project Engineer (Construction)

- Agreed that there is a major issue surrounding quality issues and defects in the industry
- My experience has been working with a mid-tier construction company delivering higher-end apartments buildings, typically in mid-rise projects in South-East Queensland.
- Given our client types we have high expectations regarding the quality of our apartments.
- Defects are inevitable though and part of my role is reviewing apartments pre-handover and arranging rectification works as required.

- Normally this is cosmetic or install/design errors, for example installing the wrong type of shower head or door. Generally these are straightforward fixes.
- There can be issues with subcontractors and we monitor ours closely and develop long-term relationships to incentivise quality work.
- Perception issues impact us also, and make our clients more wary with many choosing to engage independent inspectors as part of the handover process.
- It would be good to direct focus from finding and rectifying defects post-construction, to ensuring they are identified and fixed during the build.

4.4.2 Summary

The results of the industry expert interviews will be summarised below. Any common themes or highlighted areas will assist in directing defect reduction activities and future research. The key themes and findings were as follows:

- All interviewees agreed that there are major issues with quality and defects in the apartment construction industry.
- Despite receiving much of the blame, certifiers were generally performing their role to the extent possible and given time and access constraints.
- The push towards Design and Construct (D&C) contracts, and that through fixed price contracts and imcomplete design documents this had seen a deterioration in the quality of buildings delivered through this contract type.
- Reputational matters were highlighted by almost all participants. Buyers often do not know who is building their property, and hence there is little incentive for smaller developers to build or protect a reputation.
- Declining quality of design work and documentation due to increasing reliance on graduate, offshoring and low-experience engineer work.
- Most works are packaged out to subcontractors as fixed price contracts, and these subcontractors are relied upon to inspect and verify their own work.

5 Conclusions

5.1 Introduction

The goal of the project was to gain a better understanding of the defects occurring within mid-rise and higher residential apartment buildings in Australia. This was considered necessary due to a rapidly expanding volume of these building types being constructed in Australia, becoming a significantly larger portion of the total dwellings being constructed and occupied. This was also necessitated by a growing number and profile of defects occurring within these building types.

5.2 Discussion

The first aim of the project was to gain a thorough understanding of the literature with respect to apartment defects. A thorough literature review was undertaken and themes within the review supported both the need for the project and the limitations and issues that have prevented similar research. The review highlighted that access and availability of information with respect to defects would be a major constraint and this proved to be true. It also identified certain defect types such as waterproofing and structural as major concerns and again – the latter phases of the project supported and reinforced these findings. Little research had been done within Australia to this time however a number of reports have been published in the last 18 months, demonstrating a growing need in this area of research.

The next two aims of the project were to develop a framework for analysing and collecting data on defects, and to collect and analyse that data. The literature review helped to inform the framework, as a defect categorisation method was developed primarily from the literature, it also aided in the design of the data collection tools of the online questionnaire and interview. The online questionnaire collected data from 104 apartment occupants and additionally 6 interviews were conducted with industry experts. This met with target sample size requirements and the insight from the industry experts helped provide additional context to the questionnaire defect data collection.

The final project aim was to determine the overall risk presented by each defect type and to review potential causes. The questionnaire involved the analysis of overall defect risk, and two significant outliers in waterproofing and structural defects were highlighted. Waterproofing defects were 1.9 standard deviations above the mean and structural defects were 1.37 standard deviations above the mean of all defect types reviewed. A second tier of risks highlighted included electrical, light and data,

hydraulics and corrosion. The above would therefore form the target defect areas sought by the project.

The expert interviews found a number of key themes highlighted by participants which are contributing to lower standards in apartment construction. Key to these were the push towards Design and Construct (D&C) contracts for delivery of these buildings, as this tendering was often done with imcomplete documentation – leading to design undertaken during construction causing discrepencies. They also noted reputation was not considered by buyers hence unscrupulous developers were more likely to operate in the industry. Subcontractors were also often relied upon to inspect and certify their own work, creating conflict of interest issues. Also highlighted was a lowering standard of engineering work due to increasing use of graduates and outsourcing.

The study also highlighted availability and access to defect information is a significant issue for the apartment sector. Additionally, the defect cause review from the literature found issues relating to information management and communications within apartment project teams. Other common defect causes identified were time pressures, workmanship, management strategy and motivation.

5.3 Limitations

As has been noted in the methodology section, there are noteworthy limitations that must be considered with respect to the research. Availability of information was a limitation identified early within the project stages. Access was sought to a variety of previous defects from government records and private researches, however no permissions were granted or prior detailed defect information made available. While the data collection obtained the necessary data, this information could have been used to crosscheck new data and to provide more detailed review defect types.

The invitation to the online questionnaire was distributed to almost 700 apartment owners, however the response rate was relatively low. Time constraints limited the ability to undertake additional printing and data collection, or to supplement these numbers with more in-person data collection. The invitation was also distributed only to the Brisbane area given time and budget constraints.

Access to willing industry professional participants was limited, and though this was expected in the initial research design the opportunity to interview a higher number and broader range of industry members could have improved the interview sections findings. Many industry members were too busy

to assist in student research and additionally may have been deterred by the topic of defects, as this can have reputational concerns for the individual and company.

5.4 Further Research

Throughout the study, a number of areas where future research would be beneficial were identified. These areas are noted below as follows:

- Further study of impacts created by defects to apartment occupants, including quantifying the impact.
- Review of causes of delay to defect rectification, as long delays to rectification were observed.
- Study of the impacts created by delayed defect rectification.
- Broad review of procurement types used for apartment buildings in Australia, including review of defect incidence and severity by procurement method.
- Investigate potential of public rating system for apartment developers.

6 References

Aljassmi, H, Han, S & Davis, S 2014, 'Project Pathogens Network: New Approach to Analyzing Construction-Defects-Generation Mechanisms', *Journal of Construction Engineering and Management,* vol. 140, viewed 16 March 2022, <https://ascelibrary.org/doi/10.1061/%28ASCE%29CO.1943-7862.0000774>.

Aljassmi, H, Han, S & Davis, S 2016, 'Analysis of the Complex Mechanisms of Defect Generation in Construction Projects', *Journal of Construction Engineering and Management,* vol. 142, viewed 16 March 2022, <https://ascelibrary.org/doi/10.1061/%28ASCE%29CO.1943-7862.0001042>.

Atkinson, AR 1999, 'The role of human error in construction defects', *Structural Survey,* vol. 17, pp. 231-236, viewed 22 March 2022, <https://www.emerald.com/insight/content/doi/10.1108/02630809910303006/full/html?skipTracking=true>.

Atkinson, AR 2002, 'The pathology of building defects; a human error approach', *Engineering, Construction and Architectural Management,* vol. 9, pp. 53-61, viewed 22 March 2022, <https://www.emerald.com/insight/content/doi/10.1108/eb021206/full/html>.

Australian Bureau of Statistics 2016, *2901.0 - Census of Population and Housing: Census Dictionary, 2016,* Canberra, Australian Capital Territory, viewed 26 April 2022, <https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/2901.0Chapter29902016#:~:text=Flat%20or%20apartment%3A%20This%20category,common%20entrance%20foyer%20or%20stairwell.>.

Australian Bureau of Statistics 2016, *6291.0.55.003 - Labour Force, Australia, Detailed, Quarterly, May 2019, 2019,* Canberra, Australian Capital Territory, viewed 26 April 2022, <https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/6291.0.55.003May%202019?OpenDocument.>.

Australian Bureau of Statistics 2020, *Telling storeys - apartment building heights,* Canberra, Australian Capital Territory, viewed 26 April 2022, <https://www.abs.gov.au/articles/telling-storeys-apartment-building-heights>.

Australian Bureau of Statistics 2021, *Functional Classification of Buildings*, Canberra, Australian Capital Territory, viewed 26 April 2022, <https://www.abs.gov.au/statistics/classifications/functional-classification-buildings/latest-release>.

Australian Bureau of Statistics 2022, *Housing: Census – Information on housing type and housing costs*, Canberra, Australian Capital Territory, viewed 26 June 2022, <https://www.abs.gov.au/statistics/people/housing/housing-census/latest-release>.

Brisbane Development 2022, *Brisbane Development Map*, Brisbane, Queensland, viewed 30 April 2022, <https://brisbanedevelopment.com/brisbane-development-map/>.

Chong, W & Low, SP 2006, 'Latent Building Defects: Causes and Design Strategies to Prevent Them', *Journal of Performance of Constructed Facilities,* vol. 20, pp. 213-221, viewed 24 March 2022, <https://www.fep.up.pt/disciplinas/PGI914/Ref_topico1/LatentBuilding%20Defects.pdf>.

CFMEU 2019, Shakey Foundations – *The National Crisis in Construction*, CFMEU, Melbourne, Victoria, viewed 18 July 2022, <https://www.cfmeu.org.au/policy-research/shaky-foundations-national-crisis-contruction>.

Chong, WK & Low, SP 2005, 'Assessment of Defects at Construction and Occupancy Stages' *Journal of Performance of Constructed Facilities*, vol. 19, no. 4, pp. 283-289, viewed 21 July 2022, <https://ascelibrary.org/doi/full/10.1061/%28ASCE%290887-3828%282005%2919%3A4%28283%29>.

Cromellin, L, Thompson, S, Easthope, H, Loosemore, M, Yang, H, Buckel, C & Randolph, B 2021, *Cracks in the compact city: tackling defects in multi-unit strata housing: Final Project Report*, University of Technology Sydney and UNSW City Futures Research Centre, Sydney, viewed 15 June 2022, <https://newsroom.unsw.edu.au/sites/default/files/attachments/article/defects_final_report_for_publication.pdf>.

Dillman, D 2000, *Mail and Internet Surveys: The Tailored Design Method*, 2nd Edition, John Wiley and Sons, New York.

Easthope, H, Randolph, B & Judd, S 2012, *Governing the Compact City: The role and effectiveness of strata management*, UNSW City Futures Research Centre, Sydney, viewed 25 May 2022, <

https://cityfutures.ada.unsw.edu.au/documents/43/Governing_the_Compact_City_FINAL_REPORT.pdf>.

Flateby, T & Fehr, R 2008, 'Assessing and improving writing in the engineering curriculum', *International Journal of Engineering Education*, vol. 24, no. 5, pp. 901-905.

Forcada, N, Macarulla, M, Fuertes, A, Casals, M, Gangolells, M & Roca, X 2012, 'Influence of Building Type on Post-Handover Defects in Housing', *Journal of Performance of Constructed Facilities,* vol. 26, pp. 433-440, viewed 24 March 2022, <https://ascelibrary.org/doi/10.1061/%28ASCE%29CF.1943-5509.0000225>.

Georgiou, J, Love, P & Smith, J 1999, 'A comparison of defects in houses constructed by owners and registered builders in the Australian state of Victoria', *Structural Survey*, vol. 17, no. 3, pp. 160-169, viewed 8 April 2022, <https://www.emerald.com/insight/content/doi/10.1108/02630809910291343/full/html?skipTracking=true>.

International Organization for Standardization 1994, *Quality management and quality assurance — Vocabulary*, ISO 8402:1994, International Organization for Standardization, Geneva.

Jingmond, M & Ågren, R 2015, 'Unravelling causes of defects in construction', *Construction Innovation,* vol. 15, no. 2, pp. 198-218, viewed 10 April 2022, <https://www.emerald.com/insight/content/doi/10.1108/CI-04-2014-0025/full/html?skipTracking=true>.

Johnston, N & Reid, S 2019, *An examination of Building Defects in Residential Multi-owned Properties*, Griffith University & Deakin University, viewed 15 March 2022, <https://www.griffith.edu.au/__data/assets/pdf_file/0022/831217/Examining-Building-Defects-Research-Report-S-Reid-N-Johnston.pdf>.

Josephson, PE & Hammarlund, Y 1999, 'The causes and costs of defects in construction: A study of seven building projects', *Automation in construction*, vol. 8, pp. 681-687, viewed 26 March 2022, <https://www.sciencedirect.com/science/article/abs/pii/S0926580598001149>.

Karim, K, Marosszeky, M & Davis, S 2006, 'Managing subcontractor supply chain for quality in construction', *Engineering, Construction and Architectural Management,* vol. 13, no. 1, pp. 27-42,

viewed 16 April 2022, <https://www.emerald.com/insight/content/doi/10.1108/09699980610646485/full/html>.

Love, P 2002, 'Auditing the indirect consequences of rework in construction: A case based approach.' *Managerial Auditing Journal*, vol. 17, no. 3, pp. 138–146, viewed 9 May 2022, <https://www.emerald.com/insight/content/doi/10.1108/02686900210419921/full/html>.

Marosszeky, M, Thomas, R, Karim, K, Davis, S & McGeorge, D 2002, 'Quality management tools for lean production: from enforcement to empowerment', *Proceedings of 10th Conference of the International Group for Lean Construction*, Federal University of Rio Grande do Sul, Brazil, pp. 87-99, viewed 9 May 2022, <https://www.iglc.net/papers/details/196>.

NSW Parliament Legislative Council Public Accountability Committee 2020, *Regulation of building standards, building quality and building disputes – Final Report,* NSW Parliament, Sydney, viewed 10 March 2022, <https://www.parliament.nsw.gov.au/lcdocs/inquiries/2540/PAC%20-%20Regulation%20of%20building%20standards%20quality%20disputes%20-%20Final%20report%20-%20Report%20no%206.pdf>.

NSW Government, Strata Community Association NSW 2021, *Research report on serious defects in recently completed strata buildings across New South Wales,* NSW Government, Sydney, viewed 23 May 2022, <https://www.nsw.gov.au/sites/default/files/2021-10/Serious_defects_in_residential_apartments_research_report.pdf>.

Pearl, J 2009*, Causality: Models, reasoning, and inference*, Cambridge University Press, Cambridge, United Kingdom, viewed 8 April 2022, <https://www-cambridge-org.ezproxy.usq.edu.au/core/books/causality/B0046844FAE10CBF274D4ACBDAEB5F5B>.

Porteous, WA 1992, `Classifying building failure by cause', *Building Research and Information*, vol. 20, no. 6, pp. 350-356, viewed 25 May 2022, <https://www.tandfonline.com/doi/abs/10.1080/09613219208727242>.

Queensland Government Department of Housing and Public Works 2018, *Queensland Non-Conforming Building Products Audit Taskforce Status Report*, Queensland Government Department of Housing and Public Works, Brisbane.

Shergold, P, Weir, B 2018, *Building Confidence – Improving the effectiveness of compliance and enforcement systems for the building and construction industry across Australia*, Building Ministers' Forum, viewed 18 July 2022, <https://www.industry.gov.au/sites/default/files/July%202018 /document/pdf/building_ministers_forum_expert_assessment_-_building_confidence.pdf>.

Shoory, M 2016, *Growth of Apartment Construction in Australia*, Reserve Bank of Australia Bulletin, June 2016, Reserve Bank of Australia, Sydney, viewed 20 April 2022, <https://www.rba.gov.au/ publications/bulletin/2016/jun/3.html>.

Senate Economics References Committee 2017, *Non-conforming building products, Interim report: aluminium compositer cladding*, Senate Economics References Committee, Canberra.

Sommerville, J 2007, 'Defects and rework in new build: an analysis of the phenomenon and drivers', *Structural Survey,* vol. 25, no. 5, pp. 391-407, viewed 30 March 2022, <https://www.emerald.com/ insight/content/doi/10.1108/02630800710838437/full/html?skipTracking=true>.

Tam, V, Shen, L & Kong, J 2011, 'Impacts of multilayer chain subcontracting on project management performance' *International Journal of Project Management*, vol. 29, no. 1, pp. 108–116, viewed 6 April 2022, <https://isiarticles.com/bundles/Article/pre/pdf/3295.pdf>.

Tasmanian Government Department of Justice 2018, *Tasmanian Aluminium Composite Panel Audit Summary*, Tasmanian Government Department of Justice, Hobart.

The State of Victoria Department of Environment, Land, Water and Planning 2017, *Victorian Cladding Taskforce Interim report*, The State of Victoria Department of Environment, Land, Water and Planning, Melbourne.

Watt, D 1999, *Building Pathology: Principles and Practice*, Blackwell Science, Oxford, United Kingdom.

Unisearch 2019, *Opal Tower Investigation Final Report*, Unisearch, Sydney, viewed 21 June 2022 <https://www.planning.nsw.gov.au/-/media/Files/DPE/Reports/opal-tower-investigation-final-report-2018-02-22.pdf?la=en>.

Appendix A – Project Specification

ENG4111/4112 Research Project

Project Specification

For: Michael Denman

Title: Identifying the Causes and Factors of Construction Defects in Multi-Unit Dwellings

Major: Construction

Supervisor: Dr Fahim Ullah

Enrolment: ENG4111 – EXT S1, 2022

ENG4112 – EXT S2, 2022

Project Aim: To determine the elements of the construction process, environment, activities and other factors contributing to the creation of construction defects in mid and high-rise construction projects.

Programme: V1 - 16th March 2022

1. Review available literature on construction defect causes, defect types, contract types, quality management and related systems. Focus on key literature on causes, delivery environment factors and defect mechanisms.
2. Review building codes and regulations relevant to construction and quality assurance
3. Identify key focus areas on above research areas, determine most common defect types, defect causes. Determine most common delivery methods (contract, quality management system), determine key areas of codes and regulations
4. Design methodologies for data collection to ensure collection of relevant and necessary data
5. Collect data from available sources and categorise for analysis
6. Review themes and trends in data and identify focus areas
7. Analyse data with focus on theme and trend areas to create insight into defect causes and contributors
8. Analyse contributing factors from the project environment, construction activities and mechanisms of defect creation
9. Compare data findings with literature review findings, analyse commonality and variances
10. Provide conclusions based on data analysis and research findings
11. Identify prospective areas of future research

If time and resources permit:

12. Include end-user defects in data analysis and literature review phases of project, noting time required for some construction defects to be identified

Appendix B – Research Ethics Application

A Research Ethics Application (REA) was completed using USQ's Research Information Management System (RIMS). The ID for the REA is H22REA112. The plan has received final approval, with details and conditions outlined below:

USQ HREC ID: H22REA112
Project title: Identifying the Causes and Factors of Defects in Multi-Unit Dwellings
Approval date: 23/06/2022
Expiry date: 23/06/2025
USQ HREC status: Approved

The standard conditions of this approval are:

a) responsibly conduct the project strictly in accordance with the proposal submitted and granted ethics approval, including any amendments made to the proposal;.

(b) advise the University (email:ResearchIntegrity@usq.edu.au) immediately of any complaint pertaining to the conduct of the research or any other issues in relation to the project which may warrant review of the ethical approval of the project;

(c) promptly report any adverse events or unexpected outcomes to the University (email: ResearchIntegrity@usq.edu.au) and take prompt action to deal with any unexpected risks;

(d) make submission for any amendments to the project and obtain approval prior to implementing such changes;

(e) provide a progress 'milestone report' when requested and at least for every year of approval.

(f) provide a final 'milestone report' when the project is complete;

(g) promptly advise the University if the project has been discontinued, using a final 'milestone report'.

The additional conditionals of approval for this project are:

(a) Nil.

Appendix C – Risk Management Plan

A risk management plan (RMP) was completed using USQ's Online Safety Risk Management System (SRMS). The ID for the RMP is RMP_2022_6663. The plan has been approved by the project supervisor within the SRMS. The offline version is included below as access to the system external to USQ was removed. The RMP has been approved in the system, however as access is not available a screenshot of the supervisor's approval is included.

UNIVERSITY OF SOUTHERN QUEENSLAND

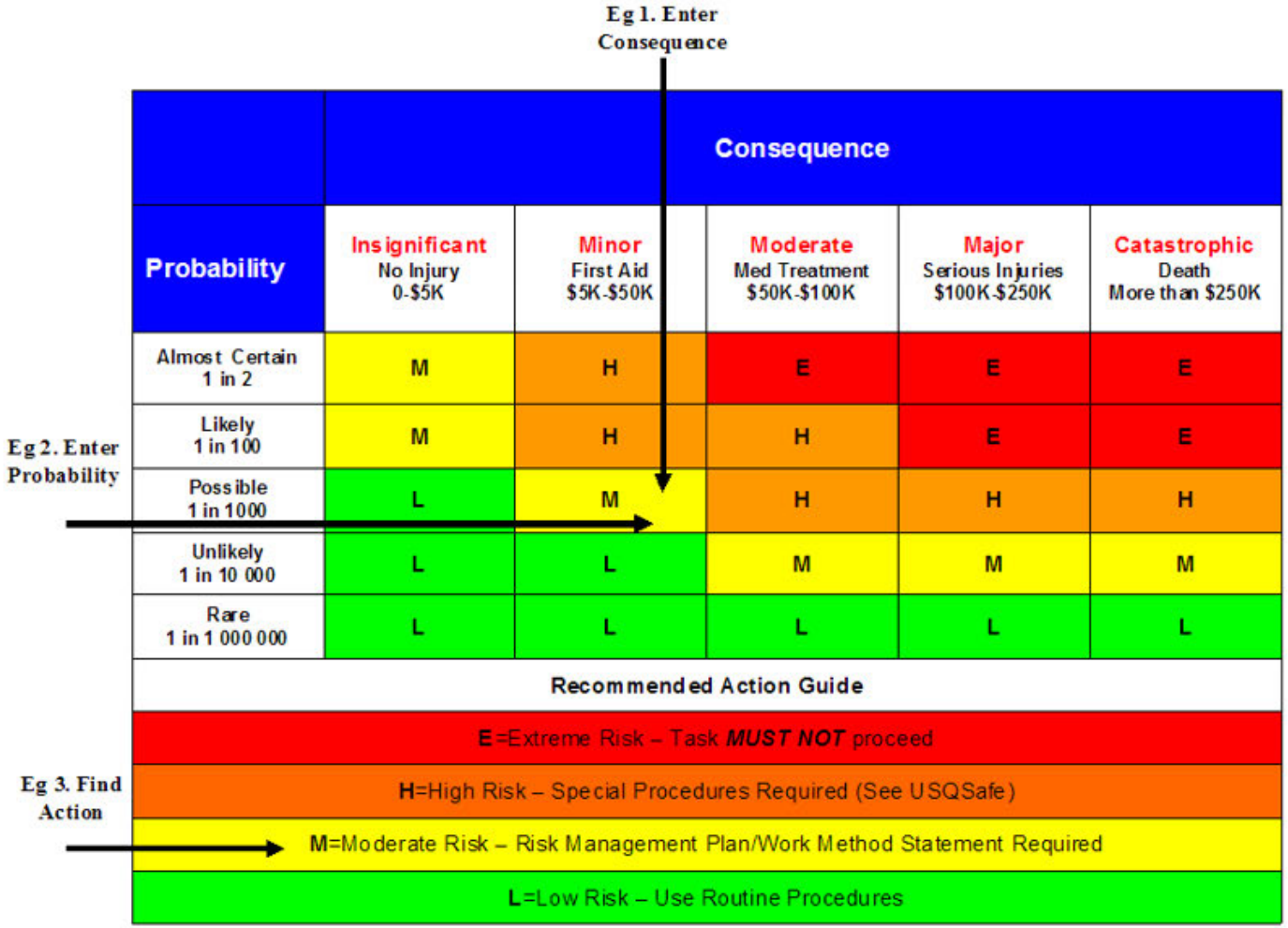
University of Southern Queensland **Offline Version**

USQ Safety Risk Management System

Note: This is the offline version of the Safety Risk Management System (SRMS) Risk Management Plan (RMP) and is only to be used for planning and drafting sessions, and when working in remote areas or on field activities. It must be transferred to the online SRMS at the first opportunity.

Safety Risk Management Plan – Offline Version			
Assessment Title:	Identifying the Causes and Factors of Construction Defects in Multi-Unit Dwellings	Assessment Date:	4/03/2022
Workplace (Division/Faculty/Section):	204060 - School of Civil Engineering and Surveying	Review Date:(5 Years Max)	Click here to enter a date.
Context			
Description:			
What is the task/event/purchase/project/procedure?	ENG4111/ENG4112 Project conducting research and data collection on construction defects		
Why is it being conducted?	To determine the causes and factors that lead to the creation of defects in Multi-Unit Dwelling construction projects		
Where is it being conducted?	Home Office, Office, Construction Sites		
Course code (if applicable)	ENG4111/ENG4112	Chemical name (if applicable)	
What other nominal conditions?			
Personnel involved	Michael Denman		
Equipment	N/A		
Environment	Home Office, Office, Construction Sites		
Other			
Briefly explain the procedure/process	Undertake project works including data collection/interviews on sites and offices as required. Remainder of works office and home office based.		
Assessment Team - who is conducting the assessment?			
Assessor(s)	Michael Denman		

Others consulted:	



Step 1 (cont)	Step 2	Step 2a	Step 2b	Step 3			Step 4				
Hazards: From step 1 or more if identified	***The Risk:*** What can happen if exposed to the hazard without existing controls in place?	***Consequence:*** What is the harm that can be caused by the hazard without existing controls in place?	***Existing Controls:*** What are the existing controls that are already in place?	***Risk Assessment:*** Consequence x Probability = Risk Level			***Additional controls:*** Enter additional controls if required to reduce the risk level	***Risk assessment with additional controls:***			
				Probability	**Risk Level**	**ALARP? Yes/no**		**Consequence**	**Probability**	**Risk Level**	**ALARP? Yes/no**
Example											
Working in temperatures over 35° C	Heat stress/heat stroke/exhaustion leading to serious personal injury/death	catastrophic	Regular breaks, chilled water available, loose clothing, fatigue management policy.	possible	high	No	temporary shade shelters, essential tasks only, close supervision, buddy system	catastrophic	unlikely	mod	Yes
Access to construction site	Trips and falls	Minor	Construction white card, escort from authorised personnel, induction as required	Possible	Moderate	Yes	Maintain close contact with site escort, use PPE (safety boots)	Minor	Unlikely	Low	Yes
Access to construction site	Impact from falling/flying objects	Moderate	Construction white card, escort from authorised personnel, induction as required	Unlikely	Low	Yes	Limit time in hot and noisy enironments, use PPE (hat, hearing protection)	Minor	Rare	Low	Yes
Access to construction site	Back/neck pain	Minor	Construction white card, escort from authorised personnel, induction as required	Unlikely	Moderate	Yes	Avoid actitivity areas, utilise PPE (helmet, eye protection)	Minor	Unlikely	Low	Yes
Extended periods of desk-based work	Back/neck pain	Minor	Ergonomic checks, timed breaks	Possible	Moderate	Yes	Orthopaedic chair, stand/sit desk	Minor	Unlikely	Low	Yes
Extended periods of desk-based work	Eye strain	Minor	Ergonomic checks, timed breaks	Rare	Low	Yes	N/A	Minor	Rare	Low	Yes

Step 5 - Action Plan (for controls not already in place)			
Additional controls:	*Resources:*	*Persons responsible:*	*Proposed implementation date:*
Maintain close contact with site escort, use PPE (safety boots)	PPE (safety boots)	Michael Denman	7/03/2022
Limit time in hot and noisy enironments, use PPE (hat, hearing protection)	PPE (hat, hearing protection)	Michael Denman	7/03/2022
Avoid actitivity areas, utilise PPE (helmet, eye protection)	PPE (helmet, eye protection)	Michael Denman	7/03/2022
Orthopaedic chair, stand/sit desk	Orthopaedic chair, stand/sit desk	Michael Denman	7/03/2022
			Click here to enter a date.
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			Click here to enter a date.

Step 6 - Approval					
Drafter's name:	Michael Denman			Draft date:	14/05/2022
Drafter's comments:	Draft version as per project specification - transferred to offline format				
Approver's name:	Fahim Ullah		Approver's title/position:		
Approver's comments:					
I am satisfied that the risks are as low as reasonably practicable and that the resources required will be provided.					

Approver's signature:		Approval date:	Click here to enter a date.

Fahim Ullah <Fahim.Ullah@usq.edu.au> Thu, May 19, 8:22 PM

to me

Hi Michael, My apologies for the delay in approval. I was in the hospital with my wife who underwent emergency surgery. She is fine now and we are back home. I have approved your RMP in the system. You should get an email about it soon.

Kind Regards

Dr Fahim Ullah
Lecturer | Construction Project Management
PhD (Construction Management and Property)
MSc (Construction Engineering and Management)
BEng (Civil Engineering-Construction Management)

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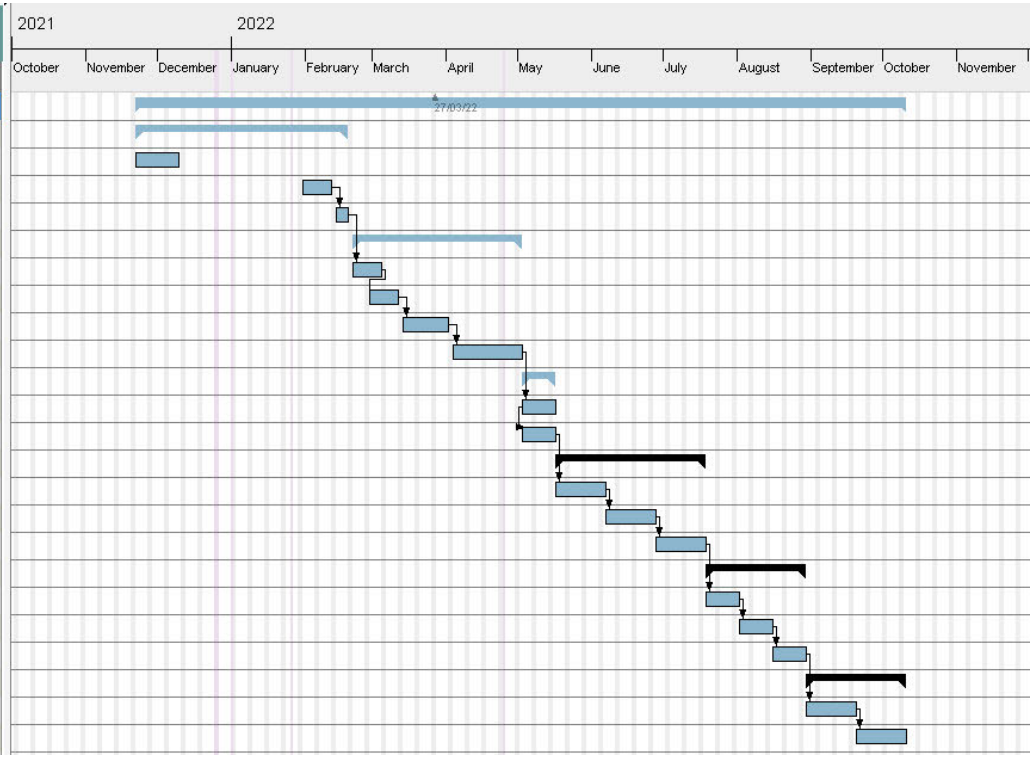
GS: https://scholar.google.com.au/citations?user=Ri6l1LgAAAAJ
Office # B431, Block B, Level 4, Springfield Campus
School of Surveying & Built Environment | Faculty of Health, Engineering & Sciences
University of Southern Queensland | QS 5-Star | Springfield, QLD 4300 | Australia

CRICOS: QLD 00244B | NSW 02225M

Appendix D – Project Plan

Name	Begin date	End date	Duration
Construction Defects in Multi-Unit Dwellings	22/11/21	10/10/22	229
Preliminary Works	22/11/21	18/02/22	64
Initial broad area research	22/11/21	9/12/21	14
Narrow of scope and literature check	31/01/22	11/02/22	10
Analyse and check resourcing	14/02/22	18/02/22	5
Literature Review	21/02/22	2/05/22	50
Determine relevant elements to research	21/02/22	4/03/22	10
Determine selection criteria for paper inclusion	28/02/22	11/03/22	10
Select literature and review	14/03/22	1/04/22	15
Analyse and document relevant findings	4/04/22	2/05/22	20
Additional Research	3/05/22	16/05/22	10
Review codes and legislation	3/05/22	16/05/22	10
Review contract and management methods	3/05/22	16/05/22	10
Data Collection	17/05/22	18/07/22	45
Design and conduct stakeholder interviews/surveys	17/05/22	6/06/22	15
Obtain building authority data	7/06/22	27/06/22	15
Obtain audit and defect reports	28/06/22	18/07/22	15
Data Analysis	19/07/22	29/08/22	30
Focus area: Project delivery environment	19/07/22	1/08/22	10
Focus area: Construction activities	2/08/22	15/08/22	10
Focus area: Defect mechanisms	16/08/22	29/08/22	10
Create Report	30/08/22	10/10/22	30
Prepare draft report	30/08/22	19/09/22	15
Prepare final report	20/09/22	10/10/22	15



Appendix E – Survey Information Sheet

University of Southern Queensland
Participant Information Sheet
Questionnaire

USQ HREC Approval number: HXREAXXX

Project Title

Identifying the Causes and Factors of Defects in Multi-Unit Dwellings

Research team contact details

Principal Investigator Details

Mr Michael Denman
Email: [redacted]
Mobile: [redacted]

Supervisor

Dr Fahim Ullah
Email: Fahim.Ullah@usq.edu.au
Telephone: [redacted]

Description

The impact of defects in construction is well established, however research into the causes of such defects is more limited. The objectives of the proposed study are to collect defect data and review causal links against the available literature on construction defects. The purpose of identifying these causes is to inform defect prevention activities and additional research.

The project aims to establish links between identified defects in Multi-Unit Dwellings and their causes. This is required to inform prevention activities during construction, inspection activities during occupation and future research. The research seeks to understand the type, location and frequency of defects. It also seeks to determine how and when such defects are identified, and the management and rectification timelines.

This project is being undertaken as part of an Honours (Construction) program through the University of Southern Queensland.

Participation

Your participation will involve completion of a online questionnaire that will take approximately 20 minutes of your time. Questions will include:

'In relation to your current apartment, are you the property owner or tenant?'

'Please provide the approximate age of the property, if known'

'Please provide details of any defects identified with the property'

Your participation in this project is entirely voluntary. If you do not wish to take part, you are not obliged to.. If you decide to take part and later change your mind, you are free to withdraw from the project at any stage. You may also request that any data collected about you be withdrawn and confidentially destroyed.

If you do wish to withdraw from this project or withdraw data collected about yourself please contact the Research Team (contact details at the top of this form).

Your decision whether you take part, do not take part, or take part and then withdraw, will in no way impact your current or future relationship with the University of Southern Queensland.

Expected benefits

The benefits of the research will be in broadening the knowledge base on construction defects in residential settings, which can have both psychological and financial impacts on residents. By improving knowledge in the area of causes

of such defects, the incidences and therefore the impacts can be reduced.The additional benefits of the research will be a gain in expertise for the student researcher, as well as a gain for the supervisor in experience supervising such work.

Risks

In participating in the interview, there are no anticipated risks beyond normal day-to-day living.

Privacy and confidentiality

All comments and responses are confidential unless required by law.

No specific identifying data will be collected or kept if provided. It will not be necessary to collect names of individuals or companies, building addresses or particulars which would allow identification of respondents to the data collection. Data will not be used or shared outside the purpose of the research paper, and no identifying information of any parties will be published or distributed.

Audio recording may be required for interviews conducted as pat of the research, for transcription and further analysis. Copies of audio and/or transcripts can be requested from the principal investigator. The recording and transcript, as well as any data collected may be used for future research purposes. Any data used for this purpose will be non-identifiable.

Any data collected as a part of this project will be stored securely, as per University of Southern Queensland's Research Data and Primary Materials Management Procedure.

Consent to participate

We would like to ask you to sign a written consent form (enclosed) to confirm your agreement to participate in this project. Please return your signed consent form to the principal investigator prior to participating in your interview.

Questions

Please refer to the Research team contact details at the top of the form to have any questions answered or to request further information about this project.

Concerns or complaints

If you have any concerns or complaints about the ethical conduct of the project, you may contact the University of Southern Queensland, Manager of Research Integrity and Ethics on +61 7 4631 1839 or email researchintegrity@usq.edu.au. The Manager of Research Integrity and Ethics is not connected with the research project and can address your concern in an unbiased manner.

Thank you for taking the time to help with this research project. Please keep this document for your information.

Appendix F – Interview Information Sheet

University of Southern Queensland
Participant Information Sheet
Interview

USQ HREC Approval number: HXREAXXX

Project Title

Identifying the Causes and Factors of Defects in Multi-Unit Dwellings

Research team contact details

Principal Investigator Details

Mr Michael Denman
Email: [redacted]
Mobile: [redacted]

Supervisor

Dr Fahim Ullah
Email: Fahim.Ullah@usq.edu.au
Telephone: [redacted]

Description

The impact of defects in construction is well established, however research into the causes of such defects is more limited. The objectives of the proposed study are to collect defect data and review causal links against the available literature on construction defects. The purpose of identifying these causes is to inform defect prevention activities and additional research.

The project aims to establish links between identified defects in Multi-Unit Dwellings and their causes. This is required to inform prevention activities during construction, inspection activities during occupation and future research. The research seeks to understand the type, location and frequency of defects. It also seeks to determine how and when such defects are identified, and the management and rectification timelines.

This project is being undertaken as part of an Honours (Construction) program through the University of Southern Queensland.

Participation

Your participation will involve partaking in interview that will take approximately 30 minutes of your time.

Questions will include:

'What role do you play in the identification and/or reporting of apartment defects, and what is the method to raise them?'

'How are defects managed once reported, particularly in regards to processes and timeframes?'

'How are reported defects prioritised in regards to rectification works?'

'By what method are the majority of defects reported? i.e. inspections, owner/resident complaints etc'

Your participation in this project is entirely voluntary. If you do not wish to take part, you are not obliged to. If you decide to take part and later change your mind, you are free to withdraw from the project at any stage. You may also request that any data collected about you be withdrawn and confidentially destroyed.

If you do wish to withdraw from this project or withdraw data collected about yourself please contact the Research Team (contact details at the top of this form).

Your decision whether you take part, do not take part, or take part and then withdraw, will in no way impact your current or future relationship with the University of Southern Queensland.

A summary of the study results will be available by contacting the Principal Investigator. The final report will also be available both through the Principal Investigator and publishing on USQ's ePrints at https://eprints.usq.edu.au/.

Expected benefits

The benefits of the research will be in broadening the knowledge base on construction defects in residential settings, which can have both psychological and financial impacts on residents. By improving knowledge in the area of causes of such defects, the incidences and therefore the impacts can be reduced.The additional benefits of the research will be a gain in expertise for the student researcher, as well as a gain for the supervisor in experience supervising such work.

Risks

In participating in the interview, there are no anticipated risks beyond normal day-to-day living.

Privacy and confidentiality

All comments and responses are confidential unless required by law.
No specific identifying data will be collected or kept if provided. It will not be necessary to collect names of individuals or companies, building addresses or particulars which would allow identification of respondents to the data collection. Data will not be used or shared outside the purpose of the research paper, and no identifying information of any parties will be published or distributed.

Audio recording may be required for interviews conducted as pat of the research, for transcription and further analysis. Copies of audio and/or transcripts can be requested from the principal investigator. The recording and transcript, as well as any data collected may be used for future research purposes. Any data used for this purpose will be non-identifiable.

Any data collected as a part of this project will be stored securely, as per University of Southern Queensland's Research Data and Primary Materials Management Procedure.

Consent to participate

We would like to ask you to sign a written consent form (enclosed) to confirm your agreement to participate in this project. Please return your signed consent form to the principal investigator prior to participating in your interview.

Questions

Please refer to the Research team contact details at the top of the form to have any questions answered or to request further information about this project.

Concerns or complaints

If you have any concerns or complaints about the ethical conduct of the project, you may contact the University of Southern Queensland, Manager of Research Integrity and Ethics on +61 7 4631 1839 or email researchintegrity@usq.edu.au. The Manager of Research Integrity and Ethics is not connected with the research project and can address your concern in an unbiased manner.

Thank you for taking the time to help with this research project. Please keep this document for your information.

Appendix G – Interview Consent Form

University of Southern Queensland
Consent form
Interview

USQ HREC Approval number: HXREAXXX

Project Title

Identifying the Causes and Factors of Defects in Multi-Unit Dwellings

Research team contact details

Principal Investigator Details

Mr Michael Denman
Email: [redacted]
Mobile: [redacted]

Supervisor

Dr Fahim Ullah
Email: Fahim.Ullah@usq.edu.au
Telephone: [redacted]

Statement of consent

By signing below, you are indicating that you:

- Have read and understood the information document regarding this project. ☐Yes / ☐ No
- Have had any questions answered to your satisfaction. ☐Yes / ☐ No
- Understand that if you have any additional questions, you can contact the research team. ☐Yes / ☐ No
- Are over 18 years of age. ☐Yes / ☐ No
- Understand that any data collected may be used in future research activities. ☐Yes / ☐ No
- Agree to participate in the project. ☐Yes / ☐ No

Name (first & last)			
Signature		**Date**	

Please return this document to a research team member before undertaking the interview.