ENG4111 Research Project

Project Preliminary Report

Integrating scheduling with quality to minimise defects in construction

Austin Tippett-Whiteman

Student Number

U1046417

In fulfilment of the requirements of

Bachelor of Construction (Management)

Abstract

This preliminary report will outline all initial aspects for the planning stages required of the ENG4111 research project. This being the third formal assessment piece for the research project, it will provide a greater understanding of the subject it is based on. This subject for the research report is to identify strategies for minimising defects by integrating scheduling with quality management.

The aim and objectives of the project is to provide relevant information on the strategies used to minimise defects in residential construction through scheduling and quality management, which will be discussed in further detail. The following objectives were further refined as to confirm what requirements were necessary to achieve the aim and objective of this research report. An extensive literature review is undertaken, providing background information to establish strategies that are effective in reducing defects in residential construction through scheduling and quality management.

Important effects are reviewed and potential outcomes are discussed in this research report. The methodology for this research project is discussed to determine the process that will be adopted to achieve the aims and objectives already set in place, this forming part of the project specification.

In addition, safety issues are mentioned and analysed to ensure there are no major concerns throughout the research. Along with safety issues, a risk assessment has been undertaken to ensure the processes part of the methodology is appropriate and risks are acknowledged. An investigation into the research requirements to identify resources that are necessary to assist in identifying schedules

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Austin Tippett-Whiteman

Student No. 0061046417

Acknowledgments

I would like to thank my supervisor Vasantha Abeysekera for his efforts in assisting my research project and helping to extend my efforts overall. I'd also like to thank the support of friends and family for their encouragement throughout the course.

Contents

Abstract ii

Limitations of Use iii

Certification iv

Acknowledgments v

Chapter 1: Introduction 5

1.1 Background 5

1.2 Aims 6

1.3 Objectives 6

1.4 Scope and Limitations 7

Chapter 2: Literature Review 8

2.1 Introduction 8

2.2 Scheduling 8

2.3 Quality 8

2.4 Quality Management 9

2.5 Defects 9

2.5.1 QBCC Results 12

2.6 Integrating Quality with Scheduling 13

2.7 Importance of quality-led scheduling in residential construction. 13

2.8 Quality in construction schedules 19

2.9 Defective work as a result of poor quality-scheduling 21

2.10 Scheduling strategies used to minimise defects in construction today 22

2.11 Specific scheduling types to be used for high rise residential construction 24

2.12 Strategies for managing finishing trades to improve quality 28

2.13 Quality management checklists for scheduling 29

2.14 Benefits of a quality-led schedule 35
2.15 Factors influencing the development of a schedule 35
2.16 Consequential Effects 38
2.17 Summary 38
Chapter 3: Methodology 39
3.1 Overview 39
3.2 Literature review methodology 39
3.3 Data collection 40
3.3.1 Case study: Multi-story apartment complex 40
3.3.2 Interviews 40
3.3.3 Develop a strategy or blueprint that can be implemented 42
3.4 Establish the strategy's relevance for minimising defects 44
3.5 Safety Issues 45
3.6 Resource Requirements 46
3.7 Ethics Approval 46
3.8 Timelines 47
3.9 Preliminary Report Summary 47
Chapter 4: Results 48
4.1 Introduction 48
4.2 Case Study 48
4.3 Interviews 51
4.4 Contractors Interview 52
4.4.1 Contractor Results 52
4.4.2 Contractor Summary 63
4.5 Subcontractor Interview 65

4.5.1 Subcontractor Results 65
4.5.2 Subcontractor Summary 81
4.6 Discussions 82
4.6.1 Contractor Results 82
4.6.2 Subcontractor Results 85
4.6.3 Case Study Results 87
4.7 Results Analysis 88
Chapter 5: Conclusion 89
5.1 Introduction 89
5.2 Discussion 89
5.3 Further work / Recommendations 90
5.4 Limitations 91
5.5 Future research 91
References 92
Appendices 95
Appendix A – Project Specification 95
Appendix B – Timeline 96
Appendix C – Ethics Approval Letter 97
Appendix D – Interview Consent Forms 99
Appendix E – Information Sheet 105

Chapter 1: Introduction

1.1 Background

As a building cadet with Pradella Constructions currently working on a multi-story construction project, the research topic came about seeing first hand defects in the finishing trades. This has been a bit of a problem and has inspired myself to take on this project as enthused by my supervisor. In every building there is a stage that so many trades are involved in to the extent that trade-density is very high and the potential for problems is likewise high. This being the reason that the need for better improved quality, in particular through scheduling to minimise defects is important and could possibly be a foot forward in the construction industry if a successful blueprint can be achieved. Therefore I have found an interest in the research topic and hope to achieve a solution to the ever existing defects that remain after and during the construction phase.

Having firsthand as mentioned above been involved with defects and completed registers for defects, this has provided a great insight on the issue. This process is completed by walking through apartments and taking photos on an iPad and uploading electronically a register through a software used by Pradella. The company schedules defect work when all subcontractors work are mostly complete and the process of identifying poor quality finishes and work is brought to attention. This process was very tedious and lengthy and I believe there is a better approach through better scheduling and improved quality management during the construction stage. This idea has influenced myself to seek further and find a way of achieving to minimise defects through an improved schedule with the integration of quality and hopefully benefit the industry as a whole if to be successful.

1.2 Aims

The aim of this research project is to investigate and identify strategies for minimising defects by integrating scheduling with quality management. To achieve this, there will be three sub aims that form the overall purpose.

1. Understand relevant literature for strategies that minimise defects through quality management in residential construction.
2. Develop a strategy or blue print that can be implemented and successful in minimising defects in residential construction.
3. Use the guideline and literature research in section A & B to establish the strategy's relevance for minimising defects in the construction industry.

1.3 Objectives

To achieve the aim of this project, ensuring that the following objectives are met is very important;

A. Understand relevant literature for strategies that minimise defects through quality management in residential construction.

1. Identify strategies that have been proposed by others in how scheduling can minimise defects. Moreover, suggesting that it would be possible to develop a blue-print which if adopted would minimise defects.
2. Investigate the nature of such a schedule through published literature including the notion whether such a schedule can be developed, and if so, labeling this initiative as a 'quality led schedule'.
3. Gain the opinion and advice from professionals in the industry to have a better understanding on defects, scheduling, and quality integration.
4. Apply the knowledge and experience towards a schedule to implement quality and assess if defects can be minimized.
5. Explore the benefits of a quality-led schedule and confirm its success.

B. Develop a strategy or blue print that can be implemented and successful in minimising defects in residential construction.

1. By focusing on a single apartment in a high rise residential construction project, developing a schedule for such a project will help identify if a schedule can be successful in minising defects.
2. Discuss the features of this schedule with experienced construction managers and identify and provide a hybrid/advanced schedule with a view of developing a schedule that would minimise defects.

C. Use the guideline and literature research in section A & B to establish the strategy's relevance for minimising defects in construction industry.

1. Examine a past project and investigate whether the defects in this project can be explained through the lack of compliance with the 'prototype plan' being developed.
2. Evaluate and put in use the quality-led strategy in a previous project and identify the strengths and weaknesses of such notion.
3. Confirm/reject the strategy that defects can be minimised/eliminated by following a quality-led schedule.

1.4 Scope and Limitations

The research constraints and limitations are subject to available material through referenced and peer reviewed articles.The case study will be subject to time constraints with participants due to their other commitments so data from the questionnaire will be used as a means to gather sufficient data for professional advice on the topic of creating a quality-led schedule to minimise defects.

Chapter 2: Literature Review

2.1 Introduction

To investigate a strategy in minimising defects through a quality-led schedule in residential construction will require an extensive literature review on the subject alone. Currently there being numerous ways and strategies in tackling projects and avoiding defects, there will always be room for improvement for high residential infrastructure. Investigations into literature reveal that there are varieties of strategies used day to day and in the case of residential construction on high rise projects, a strategy will need to be used to implement many factors in reducing defects. Moreover, peer reviewed journal articles have been the main source used for this review due to the authenticity and to remove poor quality work.

2.2 Scheduling

The concept of scheduling construction is to assist in managing the construction process altogether. For finishing trades, there are many types of schedules or programs that can be utilized and adopted to improve the sequence of work and quality of workmanship. Keeping in mind, this research project will aim to identify strategies on how to minimise defects through scheduling with integration of quality. The idea and purpose of scheduling is to bring to focus considerations such as sequencing, productivity, timing and quality.

2.3 Quality

Quality in construction will be a key factor in this research report, highlighting how quality integration can be achieved into a type of schedule that will be most appropriate. This idea came from the workplace first hand where from observations there were issues arising constantly through the fit out stage which than leads to more defects. Therefore the theory behind integrating both scheduling and quality will help to identify if there is a means to minimizing defects on-site in order to reduce labour and revisiting work already completed.

2.4 Quality Management

Quality management is a well-known term used in construction. It is a terminology used to help improve the industry management processes and create a more successful project. According to Romanova (2016), quality management is theactivities of an operational nature, carried out by the management and staff of the organization that affect the process of creating the final product to ensure compliance with quality, by performing a specific set of functions. This being said we can gather a simpler understanding that quality management can impact on the end product. If to say through scheduling, ensuring the processes involved are of quality will help justify and minise the number of defects created throughout the construction process. Quality management in the term of scheduling and the processes will be focused on to determine whether these defects can be reduced through quality integration.

2.5 Defects

According to Mills (2009), the construction industry is plagued by defective works and poor quality. A construction defect meaning "Defective construction refers to works which fall short of complying with specified descriptions or requirements of a construction contract, especially any drawings or specifications, together with any implied terms and conditions as to its quality, workmanship, durability, aesthetics, performance or design" (Ojo 2014). As mentioned earlier, the aim will be to reduce these defects through quality-led scheduling. Therefore it is important to note that if to identify where quality can improve the schedule in a way to resolve or reduce a defect, it will be worth implementing and analyzing whether this can change the way of construction processing. As a defect can range from so many types and its significance, not all defects will be focused on although it will be taken in consideration the most common, time consuming, and costly defects to achieve a more important result.

A paper by Shirkavand (2016) provides a very helpful table showing defect minimization measures. The table 1.5.1 shown below provides some of the defect causes and minimization measures taken into account from interviews done through professionals in the industry.

Table 1.5.1 – Defect minimization measures

Defects' causes	Defects' minimization measures
Poor planning time pressure and changes	- Plan well in advance. Client should begin with programming and deliver its part in advance and the contractors should have a good overview. - Poor communications between all actors**.** Involve operation and user representatives early in the project and in function testing, commissioning and testing suppliers perform before the handover, to do an optimal learning. - Follow-up in construction period. Actively participate in the construction meetings. Taking discussions underway and avoid exposing cases. It is uncomfortable to have discussions all the time, but ignoring them does not diminish discussions at the end of the project. **.**Try to supply more detailed project specification. It is also fully possible to hinting subcontractor which solutions are desirable. - Projects must have a dedicated project manager. Project managers should not be too busy and be involved in several projects simultaneously.
Poor execution and human errors especially in case of minor defects.	- It is important for contractor and suppliers to have full-scale internal control and have a vision to deliver flawless. **.**Client should visit the construction site several times during construction. Detect defects as early as possible in the process. Need for visiting increases towards the end. - Execute work in proper order. Activities after paint like door assemblies, moldings, ceiling mounting and assembly of technical parts should minimized.
Choosing the product of low	- Choosing products based on LCC alternatives. Avoid too choose the products and solutions just base on price.

quality and/or low cost	
Lack of interdisciplinary competence and experience in technical consultants and project managers	- Collocation of designers/consultants recommended specially in technical parts - Use independent control. It detects the defects area and show the real performance. - Increase competence makes it easier to call in the right supplier to repair defect. - Common understanding of several subjects is required
Commissioning period considered as an extra time to complete the tasks.	- Integrated testing, full-scale test, stability test, performance tests, acceptation of function tests and management, operation and maintenance documents should documented three weeks before handover and start of commissioning period. - One year of commissioning period recommended to tests the technical parts in all types of climate. - Use standard active in the contract phase. Read the contract and know the contract right to have clear pictureof what will delivered. Most of the complaints are just the developer's expectations. - Accurately documented process gives fewer discussions in the end. Documenting defects carefully with exact location of faults. Planning in advance as who should make a note of the defects under commissioning. Use camera, have templates and tables that are custom subjects and are easy to understand later to find defects.

The consequences of defects is another major cocern that leads to potential disasters. Again by Shirkavand (2016), he mentiones that eeconomic loss is typically a common loss for all stakeholders in a construction process. This meaning clients in many cases

detect defects after the handover. It becomes difficult for them to document the cause of the defects. The clients need therefore often to remedy the defects themselves. It often takes many hours to find and fix defects. Design and build contractor or the subcontractors should correct their mistakes and it is pricey. In addition, it is difficult to coordinate a process at its final stage where all potential resources are involved in other projects. Communication between parts usually happens slowly after handover than project time.

2.5.1 QBCC Results

Compared to the QBCC results for the most common defects, the list compiled from the case study in chapter four is similar although the top four are different and the order varies. The top ten defects that are most common according to the QBCC results which are based on an annual summary that includes a total of 4,793 complaints received by the QBCC about defective work in 2014/2015 (QBCC 2016). Keeping in mind that there are many other defects that are rectified during construction and do not end up getting reported and excluded from the top ten list. In saying this, the case study includes every defect notified and identified which may improve the quality and accuracy of the results.

1. Joinery
2. Tiling (floor)
3. Roof cladding
4. Painting
5. Wet areas –waterproofing membranes (internal)
6. Drainage
7. Wall cladding
8. Driveways and paths
9. Timber framing
10. Waterproofing membranes (external)

With the top ten defects according to the Queensland Building Construction Commission, it will be important to keep in mind that the research project is to focus on finishing trades in high-rise residential construction projects. Simply, the QBCC top ten allow for

residential housing projects also, therefore the list has been comprised and made relevant to the project focus type which can be shown as follows;

1. Joinery
2. Tiling (floor)
3. Painting
4. Wet areas – waterproofing membranes (internal)

Thus a final discussion for the comparison of results can be undertaken between the case study and the QBCC defects to determine the case studies relevance.

2.6 Integrating Quality with Scheduling

To integrate quality into scheduling, the errors and faults in a schedule need to be identified in order to improve or implement change. Different strategies for scheduling will be looked into thoroughly so that possible methods or rules can be adopted to produce an affective schedule that aims to minimise defects in construction. Alongside strategies for scheduling, factors that evolve around quality from certain aspects of schedules will be highlighted to determine or identify possible weaknesses in common schedules used today. The idea of integration as such may be achievable after understanding what quality means to a schedule which will be discussed in much more depth.

2.7 Importance of quality-led scheduling in residential construction.

Construction today requires extensive planning and organizing to ensure a quality end result for the build itself. For a project manager's position, it is assured that in his shoes you will need to achieve the required goals within the plan, which leads us to scheduling. According to Mubarak (2015), scheduling is just one part of the planning effort and the determination of timing and sequence of operations in the project and there assembly to give the overall completion time. With this information, it is clear that scheduling will assist in many aspects of construction to improve where necessary. In particular, two items mentioned relate very well with ensuring a quality finish, these are to improve work efficiency and also to coordinate amongst trades and subcontractors to expose and adjust conflict to overall improve the flow of work potentially(Mubarak, 2015). With this

in mind, the schedule developed will vary between projects, ensuring the best of both worlds between the main contractor and subcontractors during construction. Achieving efficiency and coordination on-site will improve the quality side of construction and benefit the scheduling accuracy in comparison to completion dates and aims that subcontractors can attain.

For the first item, work efficiency relies heavily on distribution, with evidence from a performance survey undertaken in Saudi Arabia on different types of construction projects, the causes of delay were mainly due to time overrun. With such evidence, this can also be impacted not only from poor scheduling but the quality of work efficiency (Assaf, 2006). If a quality schedule were to be utilized, ensuring that durations and quantities are correct, the work efficiency shall improve with the assistance of coordination from the schedule and those who perform the works involved. For instance, the case of residential apartments in a high rise development, the repetitive nature of work involved would require a profoundly scheduled structure that is sequenced, so to improve the work efficiency overall. This will theoretically lead to better productivity and more accurately define the dates of which work can be complete within a realistic timeframe.

Secondly, coordination between trades and subcontractors on site is very important so that to avoid poor quality work and to keep on schedule. Coordination is crucial due to having the power to improve quality, time, and to avoid delays on-site.Aziz (2013), explains the work behind the Last Planner System (LPS), in simpler terms, a conceptual system that aims to shift the focus of control from the workers to the flow of work that links them together. It is a very useful tool for managing the construction process, and continuous monitoring of the planning efficiency, to assist in developing foresight, smoothing workflow variations, and reducing/removing uncertainties plaguing construction processes. Mossman (2005) warrants that the LPS can be defined as a system for managing the network of relationships and conversations required for program coordination, production planning and project delivery, by promoting conversations between trade foreman and site management at appropriate levels of detail before an issue becoming critical. LPS in construction is known as a pull controlling methodology

which allows activities to commence once all constraints are removed(Seppänen, 2010). This being considered for scheduling purposes will help resolve and foresee potential issues with trades working together and clashing when overlapping or sequencing works. Hence, this type of system can be considered a quality attribute if being used to benefit an overall schedule of works in order to reduce poor quality work and ultimately mitigate defects during the construction phase.

Sequencing construction activities is an important part of developing a quality-led schedule. With reference to site foreman and management on-site, it is critical that the processes and procedures they put forward onto the subcontractors is correct as this can determine the end result and the pace at which the build itself develops. According to the guide of the United States Government Accountability Office (GAO), there has been report that there is a relationship linking good quality-led scheduling utilized early in the project life cycle and the ultimate success of the project(Bragadin, 2015). This paper advises that if the scheduling process is picked up early, allowing to foresee potential delays and the like, ways around the issue and solutions can be discussed and utilized for a better outcome. For reducing defects in residential construction for example, this may be to identify the labour requirements for painting, having the potential to delay fit off works such as electrical, bathroom accessories, flooring and more. In saying so, an understanding of the project and sequence for construction is vital, ensuring that there are no issues involving efficiency of work, coordination, and overlapping of trades.

A key element for quality-led scheduling as suggested by Callahan (1992) cited in a paper byBragadin (2015) is the ‘3S’ rule for construction planning and scheduling, meaning that the production of construction should include safety, space, and sequence which can be argued improves not only the time for works completed but also the quality of the project in its entirety. Safety for construction workers is vital, and in fact impacts on the sequencing. For instance take perimeter scaffolding, where after completion of a ground slab, scaffolding will need a hop-up well above the working level platform of the formed deck the subcontractors will need to construct and work on. A hop-up can be defined as the process of having perimeter scaffold around a building extended vertically to keep above the floor level being constructed. Ensuring a perimeter scaffold hop-up

takes place after every suspended slab has been poured ensuring that the subcontractors have a safe working place for the next suspended slab.

For the space rule, there are many different works that rely on each other due to physical or technological dependencies between construction activities(Bragadin, 2015). An example could be that once an internal partitioned wall inside a unit amongst a residential high rise building is sheeted with plasterboard on one side, the other side of the studs/wall is exposed. This wall is to be sheeted once the electrical services or any other services required are installed to proceed with finishing the walls i.e. patching and painting. In regards to quality, this aspect of space is a big impact on avoiding overcrowded work spaces, ensuring that subcontractors have room to work effectively without trying to work over another type of trade/installer. This will improve an individual's quality of work and thus a less defective outcome, saving time and money revisiting an area where a defect is identified. Moreover the safety rule is concerned with preventing contemporary use of the same space by different crews/activities at the same time, ultimately affecting the sequence efficiency. This relating very well to the space requirement mentioned before. Potentially, space and safety will eliminate poor quality approaches to construction and assist in an affective schedule that aims to minimise defects.

Speaking of sequence(Bragadin, 2015), the third rule of the '3S' theory is focused on the construction operations and project phases which in hindsight impact on the safety and space on-site. Sequencing is not best achieved without the use of Location-Based Planning (LBP) (Bragadin, 2015). This type of planning breaks down the project into smaller locations that can then be managed separately and made simpler for the subcontractors and leading hands to understand and follow. This may be schedules focused on areas like structure and finishes per floor level, façade, or landscaping programs, which can be accomplished through the bill of quantities (BOQ). A BOQ in workload terms, define all the work involved and what must be completed before a crew can move onto the next location. This quantity of data forms the location-based plan. Durations are worked out for scheduling purposes by multiplying the quantities in each location by the labour consumption factor (man-hours/unit) and dividing by the crew size

on any specific location within a project so that LBM can be used not only on repetitive projects but more complicated projects (Seppänen, 2010).

LBP also integrates the use of the Critical Path Method (CPM) into quality scheduling. With integration of the CPM, scheduling is able to consider tasks composed to multiple locations, resulting in layered logic forming from the ways that logic generation can be automated (Seppänen, 2010). With implementation of an augmented CPM algorithm, this allows for a schedule to consider continuous labour flow by delaying and juggling start dates for tasks so work can be continuous for all trades on-site. Another aspect to consider in scheduling construction projects are buffers and lags which are well known in the CPM logic. Buffers and lags are also related to the algorithm of CPM which identifies the available buffers and lags to pick up on work activities if ever falling behind (Seppänen, 2010). This type of aspect will benefit work quality if ever repairs or design issues come about. This potentially allowing time for a trade to go back and fix what needs to be done without affecting the program and before the builder's defects or development defects stage.

Given both the LPS and LBP have been identified as useful methodologies that can assist in scheduling construction effectively, combining the two may provide a lead on innovative scheduling when utilizing it with high rise residential construction. Shown below in figure 2.7.1 is an example of a flow line graph for a two building project where the location is shown on the left with the timeline above. As simple as this, it can be a starting point on developing a more detailed program/schedule that can reflect the timelines and location durations below.

The Combination of Last Planner System and Location-Based Management System

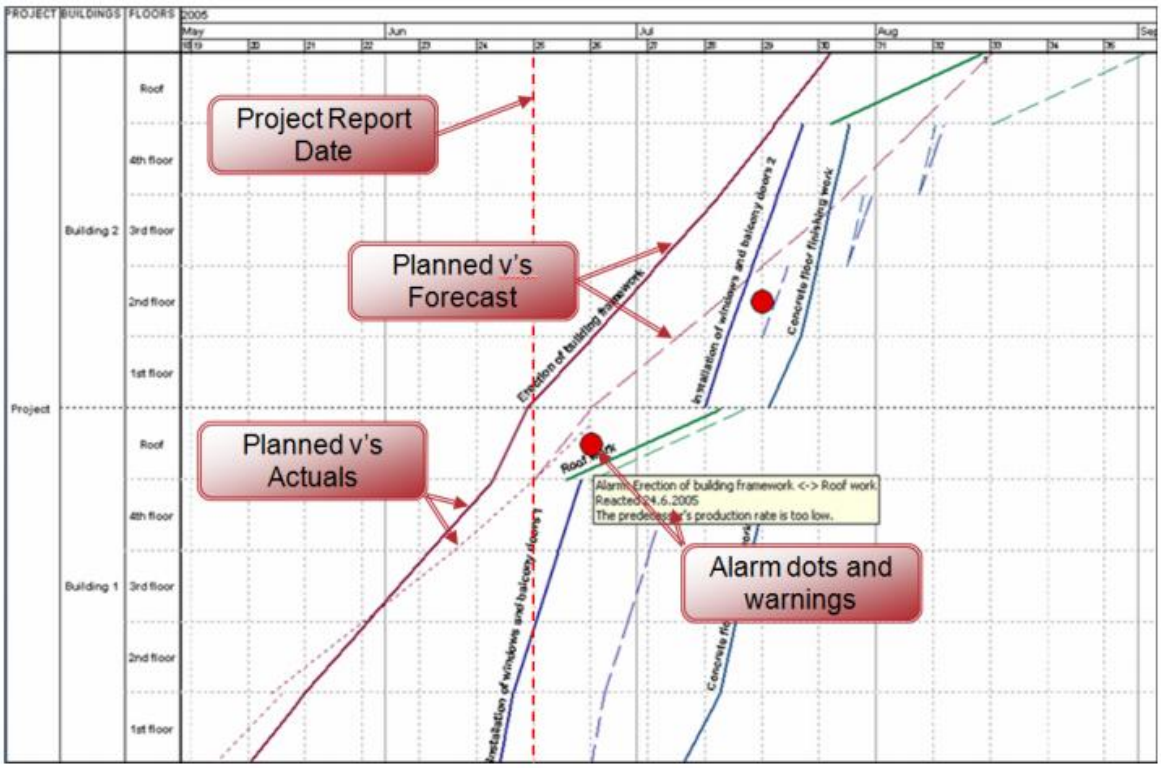


Figure 2.7.1 - A flow line figure with the plan (solid line), actual (dotted line), and forecast (dashed line), and alarms (red dots) shown

Both the Last Planning System (LPS) and Location Based Planning (LBP) as mentioned earlier, aim to achieve the lean goals of decreasing waste, increase work efficiency and productivity, and decrease variability(Seppänen, 2010). In addition the '3S' rule was an affective theory on which provided great insight for what schedules need to consider. Without scheduling it will allow for many factors to impact on the sequencing and the performance of the construction process, therefore it is important to understand the necessities and importance of why scheduling is essential. This implementation of scheduling is a good asset for quality management in a project and it will be very important and crucial to the overall success based on what types of scheduling methods and theories are adopted. Moreover, in table 2.7.2 below, there is shown a sample project providing durations with activities which can be used as a starting point to establish the basis for which durations and sequencing can be identified in order to be realistic and effective. In this case, scaffold takes two days per finished floor, external walls a two day process, base coat and wall finish one day, and window retrofit one to two days. Thus, after ground floor is complete, SP1 (first floor) will not be able to commence until walls

are complete, highlighting the issue that scheduling faces with sequencing. This matter will need to be looked over to ensure a blue print or schedule created in the research project is affective and won't have the concern for a poor quality sequence for durations of work and hence leading to impossible timeframes that create poor quality management and in due course, defects.

Table 2.7.2 - Activity list of sample project

Activity list / Space Units	Scaffolding	*Days*	Roof retrofitting	*Days*	External wall insulation	*Days*	Base coat & wall finish	*Days*	Win-dow retrofit	*Days*
SP0 – Ground floor	A – 0	2			C – 0	2	D – 0	1	E – 0	1
SP1 – First floor	A – 1	2			C – 1	2	D – 1	1	E – 1	2
SP2 – Second floor	A – 2	2			C – 2	2	D – 2	1	E – 2	2
SP3 – Third Floor	A – 3	2			C – 3	2	D – 3	1	E – 3	2
SP4 – Roof	A – 4	2	B- 4	5						

2.8 Quality in construction schedules

After extensive research and reviews, the topic for quality integrated into scheduling alone has been limited although there are a vast amount of supporting literature reviews providing types of strategies and techniques used to improve scheduling. An interesting view from Francis (2015) is the discussion about a different type of quality, that being part of the graphical aspect of which can be integrated into types of scheduling or planning strategies. Francis (2015), explains graphical quality as a way of providing the greatest number of ideas within a minimum timeframe, with the least possible writing in the smallest possible place. If to incorporate this idea further into the research project, it would be vital to assure that enough information can be provided for stakeholders and subcontractor's to follow and understand straightforwardly. It is mentioned also that the chronographical approach describes how schedule information can be communicated using tabular and graphical interfaces so that specialties, locations, means, processes and constraints on different strata show them either separately or combined, this proving to be a fairly effective scheduling strategy on paper.

As a building cadet on large high rise residential apartment buildings, seeing firsthand the type of schedules used for finishing trades for example are quite simple and affective. In saying this, it is simple enough that anyone that understands the activities in finishing an apartment can follow. Following in Figure 2.8.1 is an example of a schedule for finishing trades for the first floor on a six story Project located in West End, Queensland, which identifies the activities along the first column along with dates across the top. With reference to the green boxes on the schedule/program, it is simply the timeframe and duration the works are to be completed in. In summary, this type of schedule which is very simple and easy to follow reflects the chronographical approach quite well which provides supportive evidence seeing as it works well on-site throughout the build. This type of schedule provides a sense of quality without the complications such as the amount of information and writing, number of ideas, and minimum timeframes. Items that do support the idea of quality scheduling by Francis (2015) is the tabular and graphical interfaces which are clearly visible in the finishes schedule provided. That said, this layout of scheduling will make quite clear to subcontractors what is required, in addition, the sequence and flow of work and durations has been utlised for many jobs which can be due to the previous success a good starting point for a blue print schedule that integrates quality to minimise defects as much as possible.

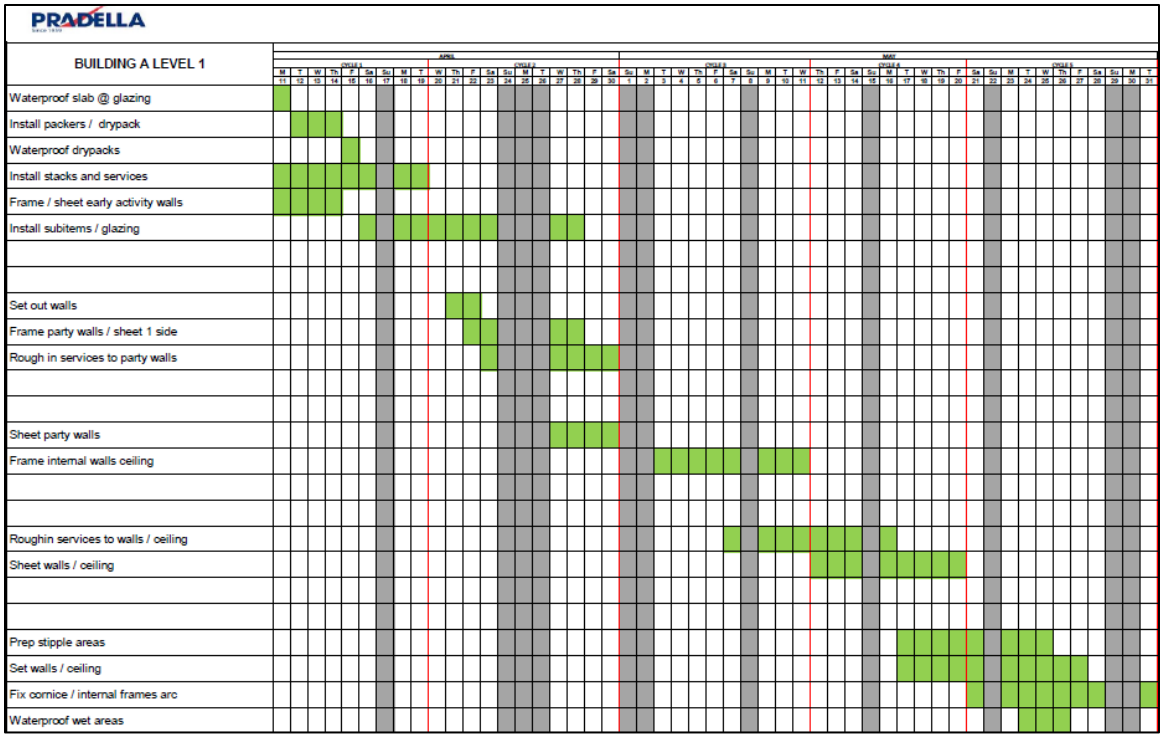


Figure 2.8.1 - Level 1 – Finishes Schedule

2.9 Defective work as a result of poor quality-scheduling

While investigating quality aspects in construction scheduling, there have been plenty of literature that highlight the concern for defective work on-site, being a major issue in the construction industry. Currently, there are many procedures in place to minimise defects and improve and meet standards without revisiting tasks for defective works. Another look on defective work in relation to quality in scheduling is the dispatching rule-based algorithms for a dynamic flexible flow shop scheduling problem as discussed by Joo (2013). In depth discussions about a time-dependent process defect rate and quality feedback based on a manufacturing processes can relate very closely with construction processes and repetitive activities. The paper which focuses on a scheduling problem in the dynamic flexible flow shop (DFFS), a manufacturing system configuration of which involves repetitive and sequenced work, similar to constructing residential apartments in a high rise building. Although the problem identified is that the defect rate depends on the setup timing, that is, the random defect rate of each job follows a normal distribution with the mean and standard deviation depending on the setup timing. Leading to the defect rate becoming higher and unstable because the elapsed time after a setup becomes longer

(Joo, 2013). Once a particular trade falls behind on work, this than leads to trades overlapping and time to complete tasks are shortened and elapsed time to meet schedule impacts the quality of work, leading to defects.

For a construction schedule, comparing to a workshop factory is not the most supporting argument, although it does have a clear idea on why quality scheduling would assist in less defective work on-site. If to implement quality-led scheduling, such as pin pointing the relevant and accurate time and sequence amongst all trades, the defective rate should hypothetically reduce and a project can be more successful.

2.10 Scheduling strategies used to minimise defects in construction today

Defects can be defined as the lack of something necessary for completeness or shortcoming. It is also defined as an imperfection, fault and blemish. Another term for defect is deficiency (Ahzahar 2011). The paper by Ahzahar (2011) goes on to explaining the definition of building failures as defects and the contributing factors lead towards these 'building failures' as follows;

- Climatic Conditions
- Location of Building
- Construction Materials
- Building Type and Change in Use
- Maintenance of Building
- Faulty Design
- Corruption
- Lack of Supervision

Although Ahzaher (2011) does not mention much to do with scheduling, this concept will be part of the lack of supervision. Moreover, the quality of site supervision has a major influence on the overall performance and efficiency of construction projects. Inadequate supervision is believed to be one of the major causes of rework (Ahzahar 2011). Therefore, when integrating a schedule with quality supervision, progress and status can be tracked and standards can be enforced during the construction process by foreman, developments, and consultants depending on the type of structure. Below is a table that

provides a relative index for common types of building defects and failures. These types of defects will be a major consideration as to try and minimise defects with the integration of quality within scheduling.

Table 2.10.1 - Rank of Relative Index for Common Types of Building Defects and Failures

No	*Defects/Failures*	*Relative Index*
1	Blemishes(Scaling, Honeycomb)	0.909
2	Corrosion of Reinforced Steel	0.827
3	Damage of Exterior Surface	0.813
4	Dampness	0.807
5	Peeling Paint	0.789
6	Roof Defects	0.722
7	Cracking(floor, beam, etc)	0.716
8	Spalling or Chipping	0.700
9	Foundation Failure	0.614
10	Structure Instability	0.476

As can be seen above in table 3.2, not all defects will relate to the finishing trades but does provide a clear view on what to improve on. The research project will implement the quality control measures discussed in hope to minimise defects through a blue print schedule. Aiming to achieve the objectives previously mentioned and mitigate the defects/failures that are most common.

As already mentioned, there are many types of scheduling strategies utilized in construction today in order to find a means to minimise defective work during the construction stage. With aim to identify whether quality when integrated with scheduling can minimise these defects, a paper by Jamaludin (2014) provides a good view on the difficulty of ensuring quality without critical consideration of time and budgets in the process. Jamaludin (2014) explains that without accurate scheduling and programming on time frames for work on-site, and sufficient resources, the quality of the project will be

decreased. This accuracy may be used from previous practices and experience or standard timeframes used broadly. Without thorough reviews on the timeframes for each activity for all construction trades, the potential for additional defects may occur. Moreover, it could be ideal to implement a computerized schedule analysis model to produce accurate and repeatable sequencing.

A computerized scheduling model should consider multiple baseline factors due to changes in the durations of activities and the logical relationships among them, as well as the impact of resource over allocation(Aziz, 2016). A schedule along the lines of advanced technology is a strategy that is becoming more and more popular in the construction industry. Aziz (2016) also mentions that to accomplish such an accurate schedule that ensures quality productivity durations is to use a daily window size in order to consider all fluctuations in the critical paths and use a legible representation of progress information to accurately apportion delays and accelerations among project parties. This will ultimately enhance the duration accuracy of trades and potentially help to reduce delays and theoretically reduce defects as the construction phase will not be pressurized to the extent of poor attention to detail by subcontractors. This methodology could be used to enhance the research project if available so that critical paths and durations determined can be more accurate, this providing sufficient time for stages of works to be completed. Helping to identify a better construction schedule that is quality based and aiming to minimise defects throughout the build.

2.11 Specific scheduling types to be used for high rise residential construction

Types of scheduling can vary greatly determining what type of works are involved and to what extent the schedule has to cover. As mentioned earlier, the Last Planner System (LPS) and Location Based Method (LBM) are very helpful advices that will improve scheduling construction activities which in the end improve quality and defective work. According to (Seppänen 2010), combining both methods of scheduling types will enhance accuracy in the overall progress. For instance, as previously shown in Figure 3.2, this type of schedule is for the location on level one of the building and is clearly showing a lot of tasks to be completed.

In addition to such scheduling types that are utilised day to day, during my time with a project team at Pradella Constructions Pty Ltd, the use of a look ahead program was implemented also. These types of schedules are usually broken up into either two or four week look ahead programs which are used to help provide a more clear view on what activities are needing to be complete within that time period which can usually be more specific than the overall fit-out schedule for one floor. Look-ahead planning details, adjusts, and optimizes the initial schedule and scopes the work in the near future(Chua, 1999), these types of schedules usually cover two or four week intervals. Look-ahead scheduling, as implemented in the Last Planner, is the bridge to link project schedules with commitment schedules. It serves several purposes (Tommelein and Ballard 1997). First, it helps break down project-level activities and shape work flow in the best achievable sequence. Second, it adjusts precedence relationships between activities for optimization and allocates resources in advance to match capacity for each activity. Third, it reduces variability in construction to achieve stable work flow by securing the availability of required resources and information. Fourth, it brings in the coordination among independent work or multiple trades. A very good example of a four week look ahead program can be shown below in Figure 3.3 for a first level fit out stage, showing what requirements are needing to be met within the time periods shown along the top row with durations in green. Providing this to subcontractors can be very helpful as to assist in being more specific on what tasks and locations are being completed first before another. Allowing a clear view for everyone to identify the reliance of trades to complete the works on time to avoid slowingdownthenext subcontractor coming through a specific area or unit. This might be painters falling behind due to plasterers slacking on setting the partitioned walls in more than a few units.

Figure 3.3: Level 1 – Four week look ahead program

Now understanding the use and purpose of look ahead programs, it would be essential in providing one for the structure and finishes of a build. In doing so, normal scheduling can be improved and more clear on what is expected in what sort of time frame. This look ahead concept could also be used to improve quality in scheduling, possibly enabling trades to be more aware of what time frames activities will need to be completed in, assisting them to organize sufficient labour and work crews that can meet the deadlines and workload required by the contractors/builders. Also introducing quality and defect sign off forms to keep improve the quality management process. If such process is introduced, defective work should be reduced due to limiting the overloaded work on subcontractors that would have previously in hindsight be forced to rush a job as an overall finishes program is not always the most informative schedule that allows identification of specific works involved and timelines.

A paper by Abeysekera (2013) provides a different view on the way construction is managed. According to Abeysekera (2013), ‘construction operations are in many ways

repetitive in nature', which in hindsight relates to basic repetitive units or 'cells' which can be matched to the concept of biological cells. The paper explains that construction is characteristically chaotic in nature, therefore quality in construction in modern society is to the point that moneys are held back as contingencies or allowances to cover the defects liability period and poor quality of work. This clearly gives the impression that defects are expected and will always continue, although the aim to try and minimise defects as much as possible will be difficult through quality scheduling. Abeysekera explains that a contractor in New Zealand has introduced an example of building a construction cell based on what resembles an embedded methodology for construction of an apartment. This was based on lessons learnt from previous construction projects which provided accurate sequencing for activities and checkpoints before proceeding to the next stage. This embedded methodology involved an apartment building mockup unit that would be constructed firstly to provide a sense of standards needing to be achieved by each subcontractor, a good way of getting the message of quality across to those building the project. A template to which is a very sufficient and effective idea to implement when scheduling and constructing multiple units at a time. This mockup unit will help identify design issues down the track early on to avoid and minimise defects.

Moreover, the idea of biological cells in construction can be used to understand cell theory. This being the functional efficiency of the cell not only to be self-sustaining, but the ability to replicate itself to develop into a fully functional multi cellular and complex unit (Abeysekera 2013). Adopting this mockup method will do exactly that, assisting in developing into a fully functional system and hopefully a scheduled flow of work that will get easier after each unit is completed of similarity. Overall minimising defects and improving the quality of work as the expectations are known.

On a different method and approach is provided in a paper by Molavi (2016), elaborates on modular construction. This came about when researching mockup construction and was very much an aspect that needed to be reviewed in regards to minimizing defects. According to Molavi (2016), the factory prefabrication environment can improve product quality. Factory workers are more permanent and reliable than site workers, so they can be much more consistent. This being said, it will be very limited to what can be

prefabricated, this may achieve a kitchen for instance but not many other features of an apartment in a multi-story building. Although, if we were to implement module construction for some aspects, it may be possible to reduce the amount of defects given the evidence from Molavi (2016) with structural precast panels. Which provide better quality control over an in-situ wall for instance. In relation to scheduling, from the previous on-site construction with material deliveries, this would definitely alter the format and possibly save time if units such as kitchens, vanities, wall frames etc. were delivered already built. On the other hand, Molavi (2016) also states that with module construction there is a lack workability on-site, given that not all structures will be millimeter perfect and this may lead to more time spent on fixing a modules piece of construction than building on-site to the as built dimensions. All in all, I think it would be difficult to schedule and sequence modular construction and defective work would potentially increase. In saying so, modular construction does has its benefits and would have potential if for certain aspects in the finishing trades, unlike precast which is a well thought out process and used broadly in the industry.

2.12 Strategies for managing finishing trades to improve quality

Finishing trades on a residential apartment building project is not an easy task to manage. Benoist (2006), mentions the concern of cumulative constraint with subcontractors, this due to limited space in each zone implying that only few subcontractors can work in the same place at the same time. This overcrowding due to compressed scheduling can result in poor quality work as the activities may be on a critical path that can potential hold up other trades. As discussed earlier, having trades rush work will reduce the quality of the outcome leading towards defects and ultimately more costs and time wasted. Overcrowding as supported by Loera (2013), indicates that a factor with a negative impact on productivity in construction projects occurs when grouping workers in confined spaces i.e. overcrowding at work. They suggest a good way to improve productivity in the projects are to introduce firstly, productivity measurement, made with data collection and further processing and statistical analysis. Secondly to evaluate productivity, based on the data obtained, a cite situation is determined thus identifying the problems. Lastly to implement improvement plans, establishing strategies and actions for improvement, with ongoing monitoring to evaluate the effectiveness and results. This

idea in relation to quality control and performance is a great proposal to control workspace space for subcontractors to potentially produce higher quality work.

Considering the scheduling side of things in regards to timeframes also, limiting the volume of work being completed in one apartment at a time for instance may lead to subcontractors falling behind on work. It can be assumed that work will be hurried. For example, if painters were asked to speed up their process of activities, the quality of work will be reduced due to pressurized work. In the case of a first coat primer for internal walls, the pre patch stage will be more extensive due to having repair more defects from poor quality work in the first place. As a result, losing more time than what the original process would have finished in. This may result to insufficient labour which would need to be brought to attention based on the size of the project itself to suit the completion dates of tasks.

2.13 Quality management checklists for scheduling

According to Bragadin (2015), a good quality construction schedule does not assure project success achievement, but it can be a good path forward. He also states the quality of planning and scheduling process is addressed by several project management guidelines including the AACE International (AACE) Recommended Practice No. 14R-90 (2006) which includes the "Schedule Quality Analysis", and the AACE Recommended Practice no. 48R-06 (2009) defining a guideline for schedule constructability review process of a construction schedule(NDIA, 2012). This Schedule Quality Analysis provides a great model that incorporates principles that could really improve the way schedules can perform for construction activities, especially for finishing trades. As follows are principles that apply to the 'Generally Accpeted Scheduling Principles' (GASP);

A	B	C	D	E	F	G	H	I	J	K	L
				COMPLIANCE TO GASP							
				Positive impact / compliance to GASP?							
Practice or Method	Description of Practice or Method	Examples	Below 7 = No Go or More Risk; 7 or Higher = Go or Less Risk	Complete	Traceable	Transparent	Statused	Predictive	Usable	Resourced	Controlled
Lag	Use lag values for wait time	Waiting for paint to dry Waiting for customer review and approval or decision	5.4	High	Low	Low	Med	Med	Low	N/A	Low
Lag	Add Schedule Visibility Tasks (SVTs) instead of using lag for wait time	10 day SVT for paint to dry 20 day SVT for customer review and approval	9.6	High	High	High	High	High	High	N/A	High

Figure 2.13.1 - Example of Planning Method to GASP Governance Model - Compliance

This model provides an insight of what quality implementation really can achieve for scheduling purposes. The GASP governance model is used to evaluate new scheduling processes by assessing whether the new schedule meets compliance to avoid leaving out any vital information. Compliance being the assessment of what activities are too risky. For quality scheduling purposes, assessing a duration with number of men may be useful, or even a certain sequence which may be adopted for use to save time but with much consideration to the risk of poor quality. In hindsight this will minimise defective work by increasing better sequencing and ensuring all necessary construction activities are completed within a timely manner and at the right time. Each project team could develop a specific governance tool that can be used by program teams on-site to help assess alignment to GASP. The aim for the project team, most likely the project manager or site

manager, is to examine each scheduling approach scenario, and then assess ease of implementation and compliance to the GASP. The idea is to address each characteristic in the table with positive intent so that the program team can decide whether a given practice or technique is likely to improve an integrated master schedule (IMS). Each schedule will vary depending on the project size, complexity, risk, and duration as well as the capabilities and experience of the builder. In case of risks or issues arising, contractors should strive to mitigate them or possibly decide to forego the approach for a less risky alternative. To create an effective schedule for finishing trades, the adoption of GASP governance model would be very beneficial to assure all aspects of construction are not disregarded or not considered into sequencing aspects of tasks to improve quality of work.

To ensure when developing a blueprint or a rule for the right schedule, there are a few items that need to be thought of in order to be effective. As shown in table 3.2following, NDIA (2012) provide a clear view on what is required and valid for a schedule, along with what makes an effective schedule shown in table 3.3.

Table 2.13.2 - GASP Principles – Valid Schedule

Generally Accepted Scheduling Principles (GASP)			GASP Narrative	GASP Essential Statement
Valid	1	Complete	Schedules represent all authorized effort for the entire contract, with essential subcontracted or other external work or milestones integrated yet distinguishable from internal work. Level of Effort may be excluded from the IMS.	**The schedule captures the entire discrete, authorized project effort from start through completion.**
	2	Traceable	Schedules reflect realistic and meaningful network logic that horizontally and vertically integrates the likely sequence for program execution. Schedules are coded to relate tasks or milestones to source or dependent documents, tools, and responsible organizations.	**The schedule logic is horizontally & vertically integrated with cross-references to key documents & tools.**
	3	Transparent	Schedules provide full disclosure of program status and forecast and include documented ground rules, assumptions, and methods for building and maintaining schedules. Documentation includes steps for analyzing the critical paths, incorporating risks and opportunities, and generating schedule health and performance metrics.	**The schedule provides visibility to assure it is complete, traceable, has documented assumptions, & provides full disclosure of program status & forecast.**
	4	Statused	Schedules reflect consistent and regular updates of completed work, interim progress, achievable remaining durations relative to the status date, and accurately maintained logic relationships.	**The schedule has accurate progress through the status date.**
	5	Predictive	Schedules accurately forecast the most likely completion dates and impacts to the program baseline plan through valid network logic and achievable task durations from the status date through program completion.	**The schedule provides meaningful critical paths & accurate forecasts for remaining work through program completion.**

This table 2.13.2 provides the principles to consider for a valid schedule. The principles are very brief and worth acknowledgment so to insure vital information is not excluded when scheduling construction activities for a project. It can be used as a quality checklist for scheduling programs and for any future projects down the track. The principles check in simpler terms that a schedule has included as follows;

- The entirety of the project activities is included in the schedule (or specific area)
- The schedule cross references activities efficiently
- The schedule is visually clear and understandable
- Status and progress can be tracked

- Accurate durations and identification of critical paths

All these factors are what bind a valid schedule for construction purposes. In achieving all these will evidently diminish the risk of missing items such as activities, correct durations, and lead towards better quality management and better quality integration into programs and schedules. All in all, the aim to minimise defects can seem more promising if a strategy or checklist is adopted and something to reflect on to ensure a schedule is sufficient for success.

Table 2.13.3 - GASP Principles – Effective Schedule

Generally Accepted Scheduling Principles (GASP)			GASP Narrative	GASP Essential Statement
Effective	6	Usable	Schedules produce meaningful metrics for timely and effective communication and tracking and improving performance, mitigating issues and risks, and capturing opportunities. Schedules are robust and functional to help stakeholders manage different levels, groupings, or areas as needed. Schedules are developed and maintained at a size, level, and complexity such that they are timely and enable effective decision-making.	**The schedule is an indispensable tool for timely & effective management decisions & actions.**
	7	Resourced	Resources align with the schedule baseline and forecast to enable stakeholders to view and assess the time-phased labor and other costs required to achieve project baseline and forecast targets. Each program is unique and uses varying techniques to load, baseline, and maintain the time-phased resources at levels that are practical and produce meaningful and accurate projections. When resource-loaded schedules are used they enable flexible updates to resource requirements as conditions change. Whether or not resource-loaded schedules are used, cost and schedule data are integrated for internal and external reporting.	**The schedule aligns with actual & projected resource availability.**
	8	Controlled	Schedules are baselined and maintained using a rigorous, stable, repeatable, and documented process. Schedule additions, deletions, and updates conform to this process and result in valid and accurate results for sound schedule configuration control and maintenance.	**The schedule is built, baselined, & maintained using a stable, repeatable, & documented process.**

The above table from NDIA (2012) provides more effective 'GASP' principles that can be defined in simpler terms as follows;

- Can be utilised as a tool for many aspects like communication, tracking, and identifying opportunities and risks.
- The schedule is reasonable in regards to resource availability.
- The schedule is adhered to and implemented for completion dates for activities.

These three points are further principles that enhance a construction schedule from the standard implementations discussed early from the valid GASP table in 2.13.2. These principles will be a good exercise when reviewing the final schedule blue print for the research project. Allowing to check each principle is achieved to support the quality of the schedule. Afterwards, it will be a matter of determining if the schedule will be successful and can be put into practice to see if defects can be reduced.

2.14 Benefits of a quality-led schedule

Benefits of a quality led schedule are paramount when it comes to delivering a large scale construction project. Duggal (2010) and Mossalam (2015) both believe that the success of a project is measured by the degree to which the program satisfies the needs and benefits for which it was undertaken. Therefore, it can be said it will be very important to create a schedule that adopts an appropriate strategy or strategies that play a part in benefiting the construction process. Benefits of integrating quality into scheduling reduce the risks involved with less quality scheduling. Accuracy and sequencing attributes are a major factor that is improved once quality is considered. Quality aspects as mentioned earlier such as types of scheduling, whether it being LPS or LBP, or even chronographical program implementation. This will provide more information for a schedule to take on and ultimately get closer to the as built construction dates and time frames. For finishing trades, defects are a long process, and to minimise this, the quality factor as mentioned earlier will need to be integrated to allow more structure to a program for subcontractors to complete tasks in a reasonable and timely manner.

2.15 Factors influencing the development of a schedule

It can be said after thorough research into the literature around quality–led scheduling that it takes a lot of understanding about construction sequencing and dependencies between trades to have a successful schedule. A paper by Ciutiene (2015)explains the lack of rational use of resources such as informational, human, and financial factors which are most of the time limited as being a major influence on planning and scheduling a project. As can be shown further on in Figure 2.15.1, a review of project determining efficiency factors as a result of successful projects is shown, where it highlights all important attributes that contribute towards success. Under the management column is the project management factor which can entail the scheduling of a project. Scheduling being one of the project management processes, which involves determining a structure of works, simply a created calendar schedule of works and suppliers. The goal of planning is to foresee what works (complexes) are necessary to be performed, foresee a schedule of their execution, calculate a need for resources required for the project and make success of that schedule (Ciutiene, 2015). This will help lead to better quality management for the aim to minimise defects in the construction process.

Table 1. Review of project determining efficiency factors (created by the authors of the study) Result of success project				
Management	Human factor	Group of people	Used management skills	Personnel selection Resolution of conflicts
Policy and strategy	Project's precision		Control	
Management of intermediates	Political and public goals	Relationship between clients Policy		Client consulting Cooperation Policy
Resources	Financing		Use of technologies and equipment	
Agreements	Precise agreement	Clear agreement Contract		
Project management	Technical conditions, designing	Project management Efficiency	Technical conditions	Technical tasks
Success indices		Yield		Search for clients
External indices	Duration of preparation of technical conditions Necessity of technical conditions	Goals	Factors related to project management Project team Factors related to project organization Attainability of resources External conditions	Support of managers Project's characteristics Managers External events Terms

Figure 2.15.1 - Review of project determining efficiency factors

In addition, Azhar (2014) has a view on comparisons of performance of common project delivery systems with respect to scheduling. Types of systems include the design-bid-build (DBB), Construction Manager at Risk (CM-at-Risk), and finally the design-build (DB) method. In relation to quality integrated with scheduling, it can be stated in Figure 2.15.2 that quality can be affected differently amongst types of project deliveries as follows;

- Stakeholders take the initial decision deadlines less seriously because changes can be made later (DBB)
- Performs well on schedule as capable of procuring long lead item early in the project (CM-at-Risk)
- Most efficient due to possibility of parallel phasing (DB)

Table 1.Comparison of performance of common project delivery systems			
Parameter	DBB	CM-at-Risk	DB
Cost	Ranks lower than others due to trend of intentional under bidding due to problems in design. This leads to change orders and thus increase in total cost of the project [10].	Guaranteed Maximum price ensures higher cost accuracy.	Perform well on cost front.
Schedule	Stakeholders take the initial decision deadlines less seriously because changes can be made later [5, 10].	Performs well on schedule as capable of procuring long lead item early in the project.	Most efficient due to possibility of parallel phasing [5].
Quality	Quality of projects delivered through this system is usually good due to presence of independent advisors and the expanded design phase.	Most efficient as independent construction professional expertise during design phase help meeting or exceeding quality of project.	Performs well as contractors are on also on board during design but they are not independent which may affect the project quality.
Administrative Burden	Administratively burdened due to the need for developing multiple bid packages, issuing them, receiving proposals, evaluating them, negotiating the contracts and overseeing its implementation.	Administratively burdened due to multiple contracts.	Less administrative burden due to lesser contracts and lines of communication.
Coordination and Teamwork	Fragmented and does not promote teamwork.	Early involvement of construction manager improves coordination.	Promotes coordination and teamwork.

Figure 2.15.2 - Comparison of performance of common project delivery systems

With integrated project delivery playing an important part in quality scheduling, these factors would need to be conquered to improve the defective work down the track.

2.16 Consequential Effects

This research project is focused on the idea of integrating quality into scheduling construction to minimise defects on-site. If a quality-led schedule can identify strategies to improve the construction process in order to reduce defective work on-site, it is anticipated that the finished product or theory could be implemented into the industry for further development through use and feedback from the end users. If any findings are discovered through the case study, this will be conveyed to all participants for review and further discussions.

Hopefully the consequential effects for the research project lead towards continued development after post graduate study. Further research into this field of construction processes could potentially provide further progress, as based on the literature review in chapter two, research could be more extensive on the topic.

2.17 Summary

To conclude, this extensive research has provided helpful information on understanding scheduling, quality, and defects. The issue was that the when integrating the three aspects, there was little available for reducing defects with quality led scheduling. In particular, there was minor information provided to apartment type complexes also. With this in mind, it was important to get a good understanding of all aspects to then move forward and gain information from experienced people in the industry which leads on to the methodology section below.

Chapter 3: Methodology

3.1 Overview

The methodology section was designed to find the best result possible to achieve the aim and objective set from the outset of this research project. The methodology chapter will be covering the approaches of the literature review, data collection process, establishing the strategies relevance to minimise defects, safety issues, resource requirements, ethical approval process and success, timelines for the research project, and s preliminary report summary.

3.2 Literature review methodology

Subsection A as part of the project specification is achieved by undertaking an extensive literature review. With no limit to the amount of articles to be reviewed although limited to the relevance and validity of the information available.

Articles will be searched in the categories of construction scheduling, quality scheduling, quality scheduling methods, construction defects etc. Articles used will be restricted to peer reviewed journal articles and published literature for authenticity. The summaries and abstracts of each article will be read over first to identify its relevance and whether they are valid for use. Once selecting an article they can be indexed in order of the categories listed below:

1. Identify strategies that have been proposed by others in how scheduling can minimise defects. Moreover, suggesting that it would be possible to develop a blue-print which if adopted would minimise defects.
2. Investigate the nature of such a schedule through published literature including the notion whether such a schedule can be developed, and if so, labeling this initiative as a ‘quality led schedule’.
3. Gain the opinion and advice from professionals in the industry to have a better understanding on defects, scheduling, and quality integration.
4. Apply the knowledge and experience towards a schedule to implement quality and assess if defects will be minimized
5. Explore the benefits of a quality-led schedule and confirm its success.

Articles that are then indexed are having literature reviews conducted to identify the information available. After extensive review, background information on quality-led scheduling is identified. All articles are then entered into Endnote software for future reference. These articles are then utilized in order to discover strategies that can minimise defects in construction and the two sections mentioned above. The results of this literature review can be found when referring to chapter two of this preliminary report.

3.3 Data collection

Data collection was accomplished through two steps which will be discussed in the following subsections. The case study and interviews was the main focus to ensure rich information could be attained to try and achieve the aims and objectives for the research project.

3.3.1 Case study: Multi-story apartment complex

Data for the case study was done through using a software called Aconex fiend which the builder utilizes for defect capturing. This allowed to filter the defects and find quantities and types that were most common to each individual trade. These results are provide in chapter four in the research report.

3.3.2 Interviews

To successfully identify strategies for minimising defects by integrating scheduling with quality (focusing mainly on finishing stage trades), a methodology will need to be developed in order to provide a procedure at which this can be achieved. Accordingly, the following procedure will be adopted:

1. Step 1: A semi-structured interview survey with selected participants on how defects could be minimised by integrating schedule (sequence activities, resourcing, templates for scheduling, etc.). These interviews will also be used to understand how defects identified by in the case study (based on the most common defects relative to the high-rise residential apartment project used) could be avoided through correct sequencing of activities and other strategies. The interview questions can be found in chapter four, identify the interview guides for both the contractors and subcontractors.

2. Step 2: A case study of a multi-storey residential apartment complex as a participant observer (as I am currently working on a multi-storey residential project) with the main intention of ascertaining the type and frequency of defects at the finishing stage, and then ascertaining whether these defects could have been excluded by developing strategies (rules, procedures etc.) for sequencing of related work so as to avoid these defects. Interviews will be conducted with in-house construction managers and also related subcontractors using an interview guide.

The methodology adopted will take place in three different criteria's which include firstly a case study, secondly a investigating the QBCC defects, and thirdly a general analyses of results. The case study which can be shown on the methodology map below will be based on defects that have been found on a project in West End, Brisbane. This information could not be found on any literature review which in turn can be quite valuable to the discussions. The participants will be asked to comment on not only the common defects on their job but also their own. This will provide a good insight on why they occur and what should be done to minimise these defects. Through these discussions that will take place on-site with those that have higher positions in construction, the results will be used to compare the comments on the QBCC defects. Along with defective work, improving the quality of a schedule will be highlighted to see if there are possible solutions for altering a process or way of sequence to help minimize the problems. Therefore the aim of the survey will be to identify what defects can be minimized through improving the quality of the schedule with the results of the case study compared to the participants input.

The QBCC investigation will enable a fair comparison of results on types of defects commonly found. As shown also on the methodology map, I have identified most common defects according to QBCC that reflect high rise residential apartment building defects that could be found. This section of the methodology will be abstracted from the literature review to help relate back to what is being said around a broad amount of projects compared to a project in West End, Brisbane. Participants will be asked questions that help to identify if these common defects can be minimized through their

knowledge in a particular area in construction along with their experience. They will advise if they see concerns and solutions to the defects in each particular case that has been identified by the QBCC. The beneficial aspect about the semi-structured survey will be the range of participants which include someone from each type of trade relative to who causes the defect and also from the contractor's point of view which will be more scheduling based on their roles in management.

Lastly will be a general discussion of results and responses from participants through the semi-structured survey questionnaires that focus on scheduling, defects, and quality in order to minimize defects. The results of the case study and QBCC results will be compared and analysed in order to possibly produce a blue print or a set of rules that should be adopted based on the results received. These discussions will be in turn compared to literature in section two of this research project. This critical reflection on the results will hopefully help identify the way of scheduling for finishing trades in apartment complexes. Aiming to find a way to better the scheduling quality so that defects can be minimized for most those that are most common in the industry today.

3.3.3 Develop a strategy or blueprint that can be implemented

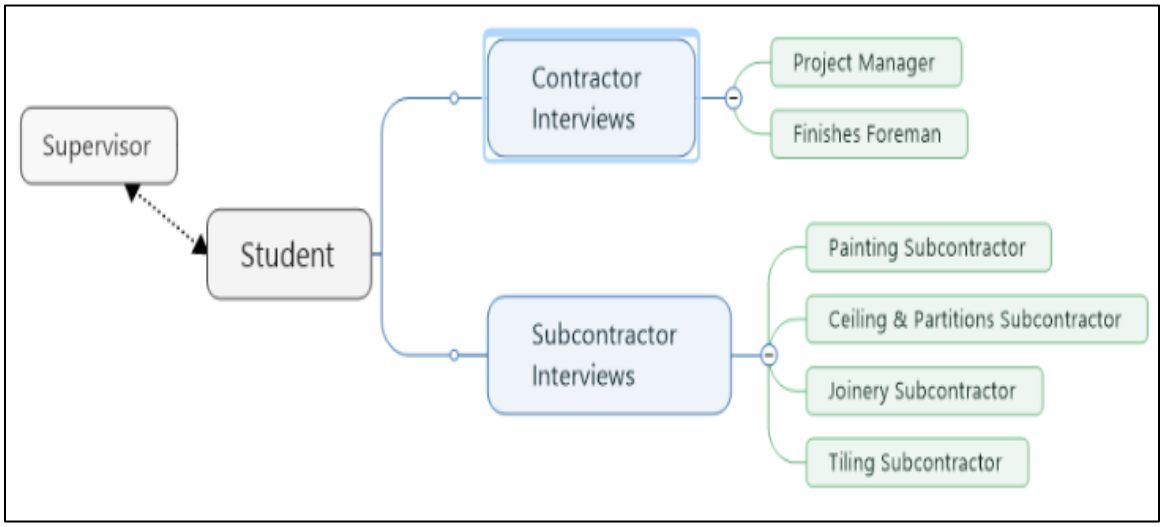
To achieve this subsection B, this strategy can be achieved through a communication plan for the project shown in Figure 5.1. As it shows, the plan was developed to ensure all parties involved would communicate to ensure I get the best results possible. This communication takes into account that I work fulltime for Pradella Constructions Pty Ltd of which allows me easier access to different company details and representatives also. In addition I have access to defect lists and have identified defects first hand on-site. Having access to defect lists will help identify problems that occur more often than others which may assist in pin pointing whether it is possible that scheduling could minimise these defects with integration of quality.

Table 5.1 and figure 5.1 describes the communication links and key people that will play a big part in the project. The communication link shows that the communication between the student and then interpreted to complete interviews with participants accordingly.

Table 3.3.1 - Communication Links

Project Particpants	Discription
1	**Supervisor**: Assist in providing feedback and progress on research project throughout the course of the year. Meetings will take place regularly to achieve this.
2	**Project Manager –** Contractor one, a representative who has been in the construction years for over 10 years.
3	**Finishes Foreman –** Contractor two, a representative who has been in the industry for over 6 years and deals with defects first hand.
4	**Painting Subcontractor –** Subcontractor one, a representative for painting who has been on over 100 projects and been in the industry for over 30 years.
5	**Ceilings & Partitions Subcontractor –** A leading hand who has been in the position for only two years although has many years' experience as a plasterer and framer.
6	**Joinery Subcontractor –** A leading hand/foreman for a joinery company for 7 years, also on the tools and closing out defects near the end of projects.
7	**Tiling Subcontractor –** A leading hand/foreman who has been in the industry for over 12 years. Currently deals with defect stages on many projects currently underway.

Figure 3.3.2 - Communication Scheme



This project will have minor special conditions as construction companies used in the interviews will require their use of scheduling and processes in the industry to stay confidential. The project will have no other special requirements. Any data provided by the construction representatives remains the property of their company and will not be released to a third party without their prior approval.

3.4 Establish the strategy's relevance for minimising defects

To achieve subsection C, examining a past project and investigate whether the defects in this project can be explained through the lack of compliance with the 'prototype plan' developed in subsection B. Evaluating and discussing the use of a quality-led strategy in a previous project and identify the strengths and weaknesses of such notion with professional in the construction industry. This confirming whether the strategy that defects can be minimised/eliminated by following a quality-led schedule is effective and relevant when aiming to minimise defects.

3.5 Safety Issues

The risk assessment in this project is very minor as the works involved is to gather a lot of information instead of physically testing materials for example. Such work will be limited to desk work within an office environment. A risk assessment has been undertaken for the desk work and is shown in table 3.3.1.

Hazard	**Likelihood**	**Exposure**	**Consequence**	**Effected**	**Control Measures**
Back Pain	Slight	Rarely	Minor Repetitive Strain Injury	Self	Routine breaks and good posture
Wrist Pain	Slight	Rarely	Minor Repetitive Strain Injury	Self	Routine breaks and good posture
Neck Pain	Slight	Rarely	Minor Repetitive Strain Injury	Self	Routine breaks and good posture
Leg Pain	Very Slight	Rarely	Minor Repetitive Strain Injury	Self	Routine breaks and good posture (foot stool)
Eye Strain	Significant	Occasionally	Minor Headaches &Eye Soreness	Self	Routine breaks and adequate lighting
Stress	Significant	Regularly	Headaches & Anxiety	Self	Routine breaks, adequate rest and relaxation between breaks

3.6 Resource Requirements

This research project mainly theory based although will encompass practical exercises when putting forward or testing the quality-led schedule. The following table 3.6.1 lists the resources required for the project.

Table 3.6.1 – Resource Requirements

Resource	Availability	Cost	Importance	Alternative Available
Laptop/Desktop	Permanent	$0	Significant	Yes
Microsoft Word	Permanent	$0	Significant	Yes
Microsoft Outlook	Permanent	$0	Significant	Yes
Microsoft PowerPoint	Permanent	$0	Significant	Yes
Microsoft Excel	Permanent	$0	Significant	Yes
Endnote	Permanent	$0	Significant	Yes
Printer	Readily available	$0	Significant	Yes
Internet Access	Readily available	$0	Significant	Yes

In addition to the above table, I will require access to project/construction managers in the industry to discuss and interview them based on quality-led scheduling. As a building cadet, I currently have permanent availability to a site and contacts along with there being no costs involved.

The driveway has been designed as an exposed aggregate finish concrete. The combination provides traditional looks

3.7 Ethics Approval

The ethics approval number is H16REA223. The approval process was not an extensive one due to the fact that all participants' names and company details would be disclosed. Strategies to minimise harm would be to have personal details disclosed, easy and straight forward interview questions, and to ensure any participant has the opportunity to decline at any time the information gathered from the interviews if required. Disclosing company names and personal details, besides the role/occupation, this provides a certain amount of confidentiality that the participants are happy to proceed with.

3.8 Timelines

Time management for the research project can be found in appendix B. This shows the stages of progress and activities taken place and the goals set from the outset. The timeline details the projects sequencing of events and shows milestone dates as well. Overall a clear and easy to read timeline that has guided the project to the finish.

3.9 Preliminary Report Summary

This preliminary report has successfully identified different types of scheduling and quality aspects that can be integrated to minimise defects in theory. This being the third formal assessment piece of the ENG4111 research project.

The aims and objectives of the research project have been clearly explained and discussed in thorough detail. The aim of the topic, which is to develop a quality-led schedule that will minimise defects in construction for primarily the fit off stages, was established, with the objectives outlining the requirements needed in order to achieve this aim. An extensive literature review was undertaken which gathered all relevant information required to establish a strategy or blue print to implement quality into a schedule for finishing trades during the fit off process to minimise defects.

Consequential effects for the research project were mentioned and confirmed. Along with an in depth comprehensive methodology that describes how the project will be achieved and approached to meet the project aims which form part of the project specification. In addition, communication strategies were also discussed and developed to enhance the performance and structure of the methodology and practical approach to the project.

Safety issues and a risk assessment was discussed for the research project. An investigation into the research requirements was also configured and confirmed, highlighting the resources that will be required in order to successfully investigate the development of a quality-led schedule that can be used in construction to minimise defects.

Chapter 4: Results

4.1 Introduction

In order to find whether defects can be minimized, it is necessary to analyse defects in construction and focus on how scheduling a processes can achieve this. This chapter aims to prove that defects can be minimised if scheduling can be improved by implementing quality. The methodology will be consistent with chapter 4 with what has been provided. The comparisons and evaluations of responses from industry professionals will be used for supportive evidence towards minimising defects. The contractor and subcontractor interviews will be taken place at the work place of the participants which will be at their respective construction sites. The case study discussion will help gather responses to most common defects found with the aim and objective to have the participants assist in finding a solution to better a schedule with quality to minimise defects. If this cannot be achieved, strategies, rules, and procedures will be discussed also to ensure rich information from the interviews can be obtained. The results will then be discussed as it is anticipated that the interviews with the assistance of the case study will highlight a solution or set of rules to overcome the defect issue in the construction industry today.

4.2 Case Study

The case study as already mentioned was a successful and beneficial process for the results of common defects. Following is a table which shows the quantities of defects for the most common on the project in West End, Brisbane.

Given below in Table 4.2.1 and 4.2.2 are the results related to the case study project of 6 stories high and 90 apartments in total.

Table 4.2.1 – Case Study Results

Trade	Defect Quantity	No. of Units	Avg. Defects / Unit
Painting	**5702**	**90**	**63.4**
Ceilings & Partitions	**2809**	**90**	**31.2**
Joinery	**2619**	**90**	**29.1**
Tiling	**1161**	**90**	**12.9**

Electrical	294	90	3.3
Shower Screens & Wardrobes	283	90	3.1
Glazing	233	90	2.6
Plumbing	109	90	1.2
Bench Tops	104	90	1.2
Mechanical	95	90	1.1
Balustrades	68	90	0.8
Floor Coverings	34	90	0.4
Fire Doors	28	90	0.3
Cleaning	13	90	0.1
Fire Services	9	90	0.1
			Avg. 150.7

The above results were taken from the archive data for a project that will be completed in late 2016. The results compared to the QBCC most common defects are very similar which has been mentioned in the literature review chapter two. Keeping in mind these results will form part of the interview discussions and provide the aim of where improvement is required. Further the above results, I have chosen to discuss about the top four most common defects in particular due to the amount of defects commonly found and the discrepancies of those with minimal defects. Therefore the interview questions will aim to discuss the trades with most defects and the most common defects in particular which is detailed in table 4.2.2 to follow. Reason being is because there is a big jump from the fourth most common defect to the fifth, hence the top four will be of most benefit for the analysis and discussions. To help further my results and gain a better understanding of the real issues, the descriptions and types of defects for these most common are provided in the following table to explain what issues in particular are causing the problem. In doing so, it can be narrowed down to the contractors and subcontractors to help identify whether we can implement quality into scheduling to minimize the particular defects or whether there are any strategies, rules, or procedures as an alternative.

Table 4.2.2 – Case Study Most Common Defect Types

Painting	Ceilings & Partitions	Joinery	Tiling
- Pin/blow holes in paint - Marks on paint - Caulking poor/inconsistent - Caulking required - Paint thin - Excess paint - Patch and paint	- Patch required - Skim plaster - Exposed screw head/setting required - Adjust door hardware - Excess plaster - Repair timber work to architraves and door jambs	- Clean excess glue off joinery edges - Adjust joinery margins to cupboards/draws - Chip in joinery/melamine - Caulking poor	- Chip in tile - Gap in grout line - Clean tile edge trim - Caulking/Silicone poor - Poor edge finish to tile - Caulking/Silicone required

Results from the case study have been attained through a vast amount of hours involved in inspecting the 90 unit's as part of the case study project in Brisbane, Queensland. Based on the most common culprits for defects and their most common type of defects according to the data collection, it can be found by using this data, it will help form the interview questions and potentially find solutions through scheduling finishing trades

4.3 Interviews

As mentioned in the methodology section, step one will be a semi-structured interview survey with selected participants on how defects could be minimised by integrating scheduling with quality through sequencing activities, resourcing, and templates for scheduling. These interviews will also be used to understand how defects identified by QBCC based on the most common defects which could be avoided through correct sequencing of activities and other strategies.

Again Step two was also covered in chapter three, being a case study for a multi-storey residential apartment complex as a participant observer as a current employee on a high-rise residential project with the main intention of ascertaining the type and frequency of defects at the finishing stage, and then ascertaining whether these defects could have been excluded by developing strategies, rules, or procedures for sequencing of related work so as to avoid these defects. Interviews will be conducted with in-house construction managers and also related subcontractors using an interview guide.

The interview questions used for this research report can be shown below which will be used for each individual interview. The minimum requirement for participants was that experience was required and knowledge and understanding about the topic was adhered to and part of their career had been involved within a management role. In depth discussions will take place on the questions shown below, the responses will help understand the real issues around defects. Opinions on resolving the defect issue with quality-led scheduling will be reviewed thoroughly. The questions asked have been formed from the literature review information gathered along with the assistance of my supervisor. This enabling an effective and beneficial questionnaire that provides as much knowledge appropriate to the research topic. The interviews are scheduled for a time frame of no longer than 30 minutes which in turn will provide enough time to gather informed answers which may benefit more than simple multiple choice questions. Also to consider is are the different roles that both the contractors and subcontractors play in the construction industry. Therefore there are two different interview guides that will be used which in simpler terms as an additional question to subcontractors. The additional

question is to quiz the participant on their own defects related to their trade and works on-site. Hopefully this will lead towards a sufficient answer as to why the defect occurred and how this could be avoided or minimised through quality integration into scheduling.

4.4 Contractors Interview

Interview for Contractors
1. What are the most common defects in high-rise apartment complex projects during the finishing stages?
2. Which of these are the most problematic?
3. In what ways can you minimize these defects through better scheduling? Any strategies, rules, templates, blueprints, standard procedure?
4. I have done a case study of a building project. I have found the following defects. Which of these do you think are the most problematic?
5. In what ways can you minimise these defects through better scheduling? Any strategies, rules, templates, blueprints, standard procedure?

4.4.1 Contractor Results

Given below are summaries from the interviews conducted with three large scale contractors. Their roles are also noted in the first columns.

4.4.1.1 Contractor Question 1

Question 1	
Contractor 1 – Project Manager	What I found was that painting touch ups, quality of setting, incomplete works and cleanliness of the units were most commonly found from my experience. Firstly with painting touch ups with the amount of trades that still come through during the defects process you're always going to get marks on the walls, there is always going to be dents to the walls, it doesn't matter how you mitigate that because there is always going to be human error, therefore there's always going to work for the painter to touch up. The other defect is quality of setting. With which the speed that we can construct there is always as mentioned earlier going to be human error. With the speed of which we build each project, unfortunately

	sometimes quality plays second fiddle to that of speed in the process but these things do need to be upheld and our standard needs to be achieved for the end result for the client. Ways in which we minimise defects for the quality of setting is a pre patch process before our defects period. This minimizes the setting and also this is done prior to the final paint so one coat of paint or one application is done to the particular surface and that remedies any issues that we have setting. The other item that you find on high rise apartment complex projects is incomplete works. Again this can be done through a sign off procedure because typically with each of our apartments gets a sign off process before the next trade enters that unit. But unfortunately as I said with which the speed that we build you have to keep pushing forward and some things do get missed. Incomplete works is sometimes a large item on our defects list. Lastly is the cleanliness of units. With the cleanliness of units it's hard to achieve a high standard in the apartment if the unit is dirty. With ways to mitigate that, our scheduling does include a scheduling period of which cleaners come through at different stages to improve the standard.
Contractor 2 – Finishes Foreman	The most common defects in these types of projects are ceiling and partitions finishes, patches to walls and poor finished ceilings. These can be of a poor quality such as pin holes in plaster after plaster is applied to a painted surface. These occur throughout the process, especially after final paint. We end up calling plasterers back in to patch what has already been patched. Also painting is of a poor quality when you have more than one trade in a unit and a painter is forced to work around other trades whilst trying to finish their product. Gloss work is of a problem using water based acrylic paint as the paint dries quickly in the humid weather that we have in Queensland. Getting a finish to these door frames or any gloss work proves to be harder for any unskilled tradesman.

4.4.1.2 Contractor Question 2

Question 2	
Contractor 1 – Project Manager	Out of the most common defects found in high rise apartment complex projects the most problematic to maintain is painting and cleaning. As I said earlier human error is a big issue and care for other people and trades works and these are very problematic due to the fact that if you go through and do the painting defects and have another trade come through after that, you will always get dents walls, scratches to walls, scratches to architraves, marks to architraves and the like. Again with cleaning items, once a cleaner goes through during our construction process with other trades doing defects in the units, typically they do leave rubbish behind them and being a foreman you can't be in every place at once to mitigate this issue. So keeping the units clean to avoid rubbish damaging the units would be ideal.
Contractor 2 – Finishes Foreman	Aside from problems from plastering and painting which was covered in question one we have had issues with joinery being installed before the final paint process. This leaves tradesman using vanities and kitchens for washing out tools leaving water on top of melamine. Which if not sealed correctly can lead to warping and damage, these are usually the hardest products to replace as they are a finished product. Whether they be tiled afterwards, vanity splash backs, plumbing fixture installs, and all of these items would need to be removed. Then reinstalling all items which leads to calling back in plumbers, tillers, silicone sealers. That being said I would have to say joinery is the most problematic defect I've come across in the industry.

4.4.1.3 Contractor Question 3

Question 3	
Contractor	To minimise defects we encounter with painting items during the defects

1 – Project Manager	process, a standard procedure of ours is to have wet trades through first. Wet trades being the likes of the tillers, silicone installers, fit off crews can also be classed as wet trades. Secondly we bring through carpenter then the plasterer, the reason why we do this is because most of the time with defects, when rectifying a defect you create another defect. For example if you had an architrave that needs to be rectified you will damage the paint work to it. If you had a tile that needs to be replaced up against the wall you will damage the plaster and the paint work and same goes for joinery, where if you have a big items like having to rectify a gable or a kicker or something of the like then that's going to damage the plaster, silicone and paint work. So a way to minimise defects as I said is to bring through the wet trades first and in the mix of that you can bring in the carpenter and finally you bring through the painter so that the painter is the last trade in that unit being that their work is precious so to speak and you don't want anybody else going in there apart from the cleaners once the painting items are done. *Noted but how would you change scheduling to minimise it I suppose, is there anything you could do to the sequence or the process that you guys as the builder use?* Prior to our defects process, it is the same deal. We do a pre patch process and the way we run it on our project is we go through and fit off our services and then we install our shower screens. That way the fit off trades aren't working in and around the shower screens as they can have defects when damaged and are quite costly. Then we go ahead and do a pre patch process on our walls that remedies any dents, marks, touch ups, and scratches that fit off trades have done to the walls which ultimately minimizes defects. After that we will go through and do our final coat process. Following the final coat we will do an initial clean in the apartment as mentioned before a good way to minimise defects is to

	implement cleanliness into the apartments as much as possible. Therefore many defects are rectified during the initial clean, minimising the builders defect process to follow. The builder's defects are items that we as a builder deem to be a defect from the subcontractor. Again as we bring the wet trades through, having the joiner, plasterer, and carpenter coming through prior to the painter, once we do that we will do a 20% clean in that unit. Once we finish the 20% clean we will bring through the developer where he picks up defects that he deems the builder has missed as a defect. Once a developer comes through and finishes his defect process we will then do the same standard procedure or scheduling with our defects process. Bringing through the wet trades again, carpenter, plasterer, and then the painter. Following that will be a final clean on the unit ready for handover. Another better way to minimise defects is by implementing rules. Some rules that we have are lockable apartments. Therefore we go through a keying system which aims to minimise traffic through the units which does help the cleanliness and reduce the quantity of defects occurring through damages. This improves the quality for the end result. We do that with two construction keys to help reduce traffic in units even more when handover time is closer. Back to our programming of the construction process with our builder's defects we will work on a construction key one which is a CK1. Once the builder's defects are closed out and rectified, the developer will come through with a construction key two, a CK2, and that drops the cylinder bearing in the entry door and that doesn't allow any subcontractor to go into that unit unless the principle contractor allows them to get in there. Other rules that we have on site to minimise defects in the units being foot prints, marks on carpet, and plaster on carpet is using covered boots. You can get boot covers that we leave outside the lift lobbies of each floor so that subcontractors can put them on prior to entering a unit. As I said this eliminates plaster, paint, rubble,

	and silicone that is left on their boots from walking around the construction site. *Going back to scheduling, how do you think your process is at the moment, would you change anything for instance in particular for the painting process, do you think this is best way to schedule their process on the job so to reduce the defects?* I believe that the way we have our programming set up through our processes at the moment is the best way. As I said you will always want to try have one trade enter that unit once. What you don't want to do is have trades going in at numerous times. This creates costs to the subcontractor, creates costs to us as the builder and variations as well because at the end of the day everybody is here to make a dollar. Although there is ways that you can minimise defects and it comes down to policing of the units and getting process right. One trade needs to be completed prior to the next trade arriving as per the schedule they are given. The last trade to exit the unit at the end of their process is the painter at all times given that painting is one of the most problematic defects occurring. *Most companies seem to have a period of time in a schedule to inspect and rectify defects after the trades have gone through. Do you think that if we reduce the builders defect period at the end of the job and have that duration put towards the trades and there quality control this could reduce defects?* Quality control is a big thing that the contractor needs to uphold. We also have our own quality control strategies. But quality control should be done as the trade leaves that unit and not as they leave the floor. Because typically how we do it is a half floor handover. So one trade will come

	through the floor and as they get half way through the next trade will start and follow suit. At the end of the day the subcontractor does complete a QA process, a quality assurance check. It is not up to the contractor to QA subcontractors work but unfortunately most of the time we do end up doing it but you can't extend the defect process given that the short time frames we are typically on when building projects. We have a deadline to stick to. If we go past those deadline we could incur liquidated damages unless you have extensions of time granted. Minimising defects is always going to be hard with the short time frames we have to stick to. But as I said these small procedures do help and do reduce defects to some degree, although you will always have defects throughout the construction process. Not one job is going to be defect free but you do hear people talk about defect free project but they do have defect processes which they achieve to close out defects prior to the end of the job.
Contractor 2 – Finishes Foreman	Apart from implementing subcontractors to use coverings for all finished items once installed to the unit to prevent damage, QA from subcontractors is required. This is to assure all finished products are handed over at a quality standard. Any strategies brought up during procedures or processes are usually taken by subcontractors and implemented accordingly. Rules that can be used through subcontractors meetings and pre-start meetings prior to work be beginning on any given day and sub meeting possibly once a week where rules are implemented and are required to be followed otherwise implementing re-induction or removal from site any subcontractor caught damaging products during defects process all subcontractors made aware that all products in install into units are of a finished standard and must be maintained implementing. *Do you think this minimizes defects or is it just another strategy to ensure it gets rectified?*

	No I think you have to put controls in so whether or not that is brought up in the meeting and subcontractors are made aware damages can be back charged. All depends on the relaying of information from foreman to workers also from management being brought down to inspect and implement procedures of any damages being rectified.

4.4.1.4 Contractor Question 4

Question 4	
Contractor 1 – Project Manager	Painting is always going to be a problematic defect. It's a precious trade and they are always going to be picked up. With ceilings and partition subcontractors, their defects are caused by the time frame of them. Typically we have issues with dry time, using a wet product that needs to dry which adds time on the duration of that process which need to be adhered to in a timely manner. Joinery can be a problematic issue with replacement of panels. Being they need to be sent back to the factory, remade, re-edged, and re-painted and sometimes that can take a two or three day process again increasing time not allowed for. With tiling, when rectifying a defect you create a defect. For instance if you have a tile needing replacement, you need to wait for glue to dry and then grout afterwards. Once grouted you'll need to reseal if it's up against a wall but prior to that you would still need to patch the wall again which increases drying time, then paint the wall and reseal to get your final product. Time is of the essence and these items become problematic with timeframes required to achieve.
Contractor 2 – Finishes Foreman	So painting as a whole, any painting to be done obviously needs to start with a clean surface which is hard enough to obtain on any building site. Walls must be free from dust, walking the pre patch prior to the final

	coat, dust must be removed from internal corners, dust should be removed from any floor coverings or the substrate slab prior to floor coverings, dust being an issue in whole will always be a problem on any building site. Especially for a process such as painting. Ceilings and partitions, plaster being a soft product as is can be damaged easily if tradesmen are not made aware to take care of plaster prior to painting processes can be damaged and can be quite problematic to have rectified. Any water issues in any building projects to plaster can be very problematic to plaster in a whole. Rectification having sheets torn out, mildew and mold being trapped in plaster being one of many culprits for this. Joinery, you can have issue from the factory being brought up to any building site. In any case with such a high demand for joinery and being how quickly the joinery is delivered can be of a substandard with glue being over sprayed once edge tape is pressed onto melamine and can be a defect and a danger to any owner with sharp edge and an unsightly finish. Tiling defects can be very problematic due to the fact that a lot of tiling is installed dover waterproofing, any tile damages and rectification that damaged the waterproofing substrate would then need to be waterproofed again and reinstalled. This can become quite costly in any building company and for subcontractors as well.

4.4.1.5 Contractor Question 5

Question 5	
Contractor 1 – Project Manager	For painting it's important to leave the painting item till last. That way every trade has the opportunity to rectify their items and then bring through the plasterer and then the painter only has to enter that unit once. Another way to minimise defects is to add on a longer duration for the QA process at the end of the subcontractors work. But again time is as the essence but unfortunately there is never enough time to instigate and fulfill the perfect QA process. It's important for the subcontractor to

	ensure their QA or ITP is done which should be the responsibility of the leading hand of that trade and ideally complete within their duration given on each particular floor. With an ITP, they have their own checklists for common defects they find within their trade. Which is prior to the builder defects being carried out. Patching items can be minimised also by leaving them as one of the last trades prior to the final defect paint process. Again the reflects back to pre-patch, an item that rectifies issues early on prior to the final paint which is an item added into our finishing schedules. This helps identify defects that aren't picked up through setting of poor internal and external joints of plaster board, cracking and expansion of plaster board that should have been cut in but have been missed and skimming of walls where glancing lights shows up once the initial coat is applied. This initial coat brings up any imperfections in the wall and defects are found and rectified sooner. Giving the walls a better finish prior to final paint processes. Joinery is usually glue on edges, screw caps missing, damaged to panels by trades or transport. These are usually minimised through ITP checklists also. Tiling defects like chipped tiles, gaps in grout are also something that ITP checklists find although the quality of this checklist review may need improvement by the person inspecting to help minimise defects. Sometimes you can have the tiling done then joinery placed on top of the tiles. Although we feel it isn't an appropriate detail due to falls to floor. If you think about it, installing a level kitchen on a falling floor or a level vanity on a falling floor it become harder for the joiner to install.
Contractor 2 – Finishes Foreman	To minimise these defects through better scheduling all trades starting with painting require more time, for all of their works to be concluded prior to builder and developer s defects being implemented. Scheduling would come into a lot of these defects giving all trades more time for procurement of all items and a better finish to their applied trade. Painting in a whole, if more time was given to ceiling ins partitions to get there

	works to a standard required by the builder, painting would then become less of an issue due to the fact the at any defects brought up after the first coat would not be such an issue, painting subcontractors could pick up minor defects instead of ceilings and partitions subcontractors being called back to rectify their defects for patching and paint. *Do you think that there is subcontractor that comes back into a unit that creates a defect after final coats?* In some instances we have delays from say shower screens, joinery, even tiling can create issues to final paint, plaster, cause scratches and dents. A process we use for tiling is to install border tiles to balconies to advance construction with balustrade install. Final processes, external and internal walls, joinery, tiling, can all be affected by trades bringing materials through units, corridors, wheel barrows, trolleys, tool boxes all have to be stored works places given to tradesman for works even flooring installation, carpet or timber floors can create damages to timber trims, architraves, door jambs, doors, any plaster walls, external walls If ceilings and partitions were given more time prior to rough in stage, they might have so many issues with walls not being straight. We implement an approval to tile, which the ceilings and partitions, tiling, waterproofing, and builder must sign off prior to tiling. This procedure works well with tiling as subcontractors are then required to more or less judge each other's work and approve the quality of the workmanship and address any issues prior to any final processes such as tiling, painting, and shower screens install. *You guys seem to use standard procedures popular to the industry. But to sum it up, do you think you can improve a schedule to minimise these most common defects as found in the case study?*

	Apart from addressing with where you sit with the market and how your scheduling works, your builder will always drive the process to be faster always with any procedure and scheduling if you can pick up time, days or weeks which is rare but days or hours are more appropriate. *But you mentioned quality processes you implement. But is there any quality process that you could put into a schedule or program, is there something your builder changes or innovates to a schedule to minimise the defects or improve quality?* One of the things that we had here is the procurement of joinery (joinery being kitchens, vanities, and robes/linen cupboards) where the lead time was approximately a week and we had tiles being installed prior to joinery going in. With that process you have more chanceof a poor quality finish to joinery. With joinery sitting on top of tiles and tiles being finished prior. As a standard we would implement wet trades before any dry trades. That would alleviate any defects before dry trades starting works. Overall defects as a whole will always happen, whether scheduling rules, templates, blueprint and standard procedure are followed to the letter, defects are a natural occurrence in any building and construction firm where you have trades consistently coming through into a small space. So to sum up, I don't finds that scheduling can minimise alleviate any defects due to the fact you will always have human error occurrences in any building practice.

4.4.2 Contractor Summary

The following summary will provide brief notes as to what the contractors talked about. The summary below will help to discuss the main ideas and issues taken from the interview answers.

SUMMARY	Contractor1	Contractor 2
Q1	Painting touch ups, quality of setting, incomplete works and cleanliness of the units.	Ceiling and partitions finishes, patches to walls and poor finished ceilings.
Q2	Maintaining paint and cleanliness of units which leads to more damages.	Joinery being installed before the final paint process. This leaves tradesman using vanities and kitchens for washing out tools leaving water on top of melamine.
Q3	Bring through the wet trades first and in the mix of that you can bring in the carpenter and finally you bring through the painter so that the painter is the last trade. Also using lockable apartments to restrict amount of traffic in units.	QA from subcontractors is required. This is to assure all finished products are handed over at a quality standard. Also notifying subcontractors that defects caused by them will be charged/back charged to them.
Q4	We have issues with dry time for paint, using a wet product that needs to dry which adds time on the duration. Patching required. Replacement of joinery panels, chipped tiles.	Painting needs to start with a clean substrate. Patching required. Replacement of joinery panels, chipped tiles.
Q5	Pre patch stage helps minimise painting defects. Joinery install prior to tiling is preferred to avoid poor finished joinery installs. QA from trades must be improved.	Increase time allowed for trades to ensure the product handed over to the next trade is of a higher standard. In summary does not believe scheduling can minimise defects.

4.5 Subcontractor Interview

Interview for Subcontractors
1. What are the most defects connected with your trade?
2. What are the most problematic?
3. In what ways can you minimise these defects through better scheduling?
4. In what ways can you minimise these defects through better ways of working? Any strategies, rules, templates, blueprints, standard procedure?

4.5.1 Subcontractor Results

Given below are summaries from the interviews conducted with the four trades that have caused the highest quantity of defect. Their roles are also noted in the first columns.

4.5.1.1 Contractor Question 1

Question 1	
Subcontractor 1 (Painting)	Most common defects I'd say would be patch and paint, marks on walls, and poor finishes to substrate. Plasterers are the most problematic part of our trade, as they don't seem to be able to finish their substrate so that we can actually move on and produce a product that we are supposed to produce. At the end of the day our finish relies on their finish. So because if they can't produce a finish, we get pushed into an area we really shouldn't be painting. That's where the defects occur. Second part of it is other trades coming in after we have finished our works/final coat and they should be in after they should procedures all done before we finish our final coat. So the plasterers and carpenters need to get the substrate up to standard so we can give the builder a decent finish. *In the case of no skirting, does this cause more defects for painter?*

	As long as the carpet layers don't smash out the bottom of the walls which they usually do, there are ways of around it. I worked for a company for over ten years on the sunshine coast where we never really had skirting on projects. In this case the carpet layers got used to it and wrap their bolsters and buy edge trimmers so when they kick and they trim they weren't scratching the bottom of the walls. There is ways around this, skirting does obviously help but skirting gets damages also and requires rectification either way.
Subcontractor 2 (Ceilings & Partitions)	The most common defects are firstly damage from other trades would be poor setting, sanding, pin holes or whatever it may be. Then the third most common would be missing hardware or sundry items. Why do you think damage happens? People are reckless, people are always in a rush and don't seem to care about anything, it's not a high priory and doesn't affect them. People in a hurry missing things and not taking their time needed to. You don't think patching is a common defect after its painting, after we do pre paint patching is a common defect which comes from damage.
Subcontractor 3 (Joinery)	One common defect would be excess glue to joinery, not coming out of the factory properly, and not clean by factory staff and seems to be rushed. Also another common defect is chips and damage caused by other trades. Rough installation is another common defect, as well as gap fills, cracking, lot of movement in building causing cracking. Missing items can also be common such as variations.
Subcontractor 4 (Tiling)	The highest defect would have to be grouting I'd say. The next most common would be fit off issues, wheeling stuff over floor tiles. Generally it happens during fit off stage. For example a shower screen fit off screwing the holes into tiles at wrong location or walking on wet

	tiles to get their works done. Majority of those kind of things come under the damage factor.

4.5.1.2 Contractor Question 2

Question 2	
Subcontractor 1 (Painting)	Once again it is having a substrate which is at a sufficient standard for us to apply our product. So unfinished plaster work, timber work, architraves that are not quite finished sufficiently so that we can put a paint product on it without excessive filling and etc. Other trades also not having their works finished, electricians, and mechanical subcontractors with air conditioning units. We should be the second last trade, carpet layers obviously after we are done because floors need to be laid but shouldn't be anybody else coming behind us. So most problematic thing is incomplete works. *What would you say the second most problematic defect?* Having works damaged by other trade coming through just by walking in and out. Just bashing their way in and out of units.
Subcontractor 2 (Ceilings & Partitions)	Damage is problematic the most because it keeps occurring so as soon as one more guy walks in damages something so that keeps occurring. What does it lead to? Leads to costing the trades money, bring extra guys on and leads to delays which extend the job for everybody. So that's most problematic in terms of you can't ever finish a unit until every single person is gone because things keep coming up in terms of other defects.

	I found that walls that aren't straight are problematic, generally picked up in pre paint so generally not picked up which is problematic. Anything major should be done previous to the defects so that the defects process for us is quite quick. Do you think that a lot of hours are spent on pre-patching? The building to go up as quick as it does there's no way you can do a quality enough job to keep moving at the rate that we do.
Subcontractor 3 (Joinery)	When you have a damaged fridge gable that can't be touched u or fixed onsite you'll need to replace it, if you don't have material on-site you got to order it from the factory which requires machined, edged and whatever needs to be done to it than need to get a guy off the contract to replace/refit it the panels. This may create more defects if the panel was already tiled around or even silicone, creating additional works and wasting time and money. This may even take paint off the wall and rip the plaster, creating more rework for other trades.
Subcontractor 4 (Tiling)	Probably goes back to the first question as well, being damages to tiles especially in wet areas where membranes and everything underneath on your substrates. Obviously you go to replace the damage tiles therefore sometime the area grows because you have to increase the waterproof lap back to the original waterproofing so basically can turn into one big night mare. It's the most problematic because it seems to be the most frequent. Of course the more it happens the more men you have to put on it to fix it than taking them away from contractual stuff and evidently makes sticking to a program slightly harder.

4.5.1.3 Contractor Question 3

Question 3	
Subcontractor 1 (Painting)	We can minimise the extra works by a way of making sure that other trades have sufficiently finished their jobs, plaster works especially. Pre paints that are on the job are huge, we spend hours doing a pre paint but it should be a 30 minute job but turn into 1 or 2 hours because once again the substrate hasn't been finishedsufficientlyfor us to paint on the walls *What's the purpose of the pre paint process?* The purpose is to make sure that it's good to go, so we coat of sealant throughout the unit and then the coat allows us to see some defects. So coater sealer goes on but if you leave bands and big set joins in middle of walls that are obvious and can see before the coat and sealant goes on it really needs to be dealt with before we actually get the first coat on and not come back and reseal half a unit because the plaster didn't do it properly in the first place. *Do you notify them to fix it or they come back and rectify it?* It's usually the supervisor on site and gets them to go back and re do works. But to minimise that time they should ensure to hand over to us the painters the first time in a lot better shape. They do rush it due to time restraints. *Besides increasing the time which would make everyone happy, is there another way to mitigate this in a schedule?* Well what happens is we have to put more men on to re do the works that we already done, so we put a coast of sealer we have to employ

	another two men and put the second coat of sealer due to the massive pre paint, if it wasn't we could mitigate that issue and save time. Either provide more time to for works or stop employing subcontractors, because the subcontracting will have them come through and smash each unit out by a way of plastering and get paid for poor quality work either way and leave multiple defects. If they had them on hourly rate they wouldn't be rushing through and leaving things nothing which they do. It's not really a scheduling issue its back to the builder saying no we can't have subcontractors doing these works, we need to have this amount of men to perform this task in this amount of time. That's the same as us painters, we are not subcontractors, and we come in on an hourly rate, but if we fall behind the builders says that we need more men to finish on time. *Do you think most programs are too tight and not realistic? Do you think it would be overall better with more realistic timeframes and work out quicker overall?* Yes for sure, in the end if the date was extended a wee bit and other trades were allowed to get work done, other trades would not need to come back through units so much and cause damage and cause multiple defects and cause multiple time.
Subcontractor 2 (Ceilings & Partitions)	The main way would be if we had more time, time is a big thing because when the set is going to set a unit (frame is going to frame) the next part of the process happens so quickly that you can't fix anything that needs to be fixed. For e.g. As soon as someone set a unit then sanded, someone is waiting outside to paint. So if you have a little bit more time to schedule, you can allow a period of a day to check things to make sure that later on it wouldn't be a problem.

	Just because you said the pace, it doesn't allow more time People say I haven't done the QA or checked the unit properly but doesn't allow me to be able to do that because there waiting outside to spray it as soon as I do. So for the painter and us, if you can allow the setup to finish the unit, sand it all and do a proper check on it, it will prove the process later on. *Do you think there's any time wasted that you could use into that time frame because there's a lot of time spent on pre patches for defects. But do you think there's any way to change the schedule to minimize that time to be put into the earlier stages or is it too risky?* One of the problems is that when you set a unit, you really need it to be painted because it shows up all the defects better. So if you sand something and then set over top of it, it doesn't sand out properly so you can see where you have done your patch. You are reliant on your setters to get it right because to fix it before its painted is a problem but doesn't mean that there are things missed like dints that can be avoided and In general we are reliant mostly on the quality of the work. *Is there any way you think you could alter the process between you and the painters that would make substrates better quality?* Time and money is a big thing, it depends on what the company or whoever is willing to pay the workers there and put up what they think to make the most money. At the end of the day the big thing comes to the company to pay the guys what they deserve to put up a certain quality of unit because at the moment the guys that's the quickest and puts up with the rubbish unit. They look at the productivity more than they do quality so the guys that are good at their job and put out the

	quality, they don't look as good as the ones the pump out the productivity. So they need to change that mindset around from productivity to quality and that's the only way to get a better result.
Subcontractor 3 (Joinery)	Could be a combination of a few things. Can be a bit of scheduling dependent on how much apartment you need to do in a certain time frame, and have guys on-site to meet the deadlines. Person in charge needs to be on top of it all. But if under staffed and trying to get a certain amount unit done on a certain amount of time that can leave little things left as it's more important to get the unit done than to fix up small defects so we don't hold up tillers and ultimately the process. It risky because we can get hit with costs if holding up other people. *Do you think there is any issues with the sequencing of the schedules provided to you?* For sequencing it's important for all trades to stay on track, if one falls short it's like a domino effect that doesn't end well and increases the duration of the job. This leaves people to skip rooms and what not and affect the sequence.
Subcontractor 4 (Tiling)	Well I think better scheduling which all boils back to how quick you need to hand over unit and handover floor. For example you are given a twelve day cycle for twelve units that's basically a unit per day. And obviously with a push like that the tradesman tend to cut corners and you also tend to have a lot of other trades working on top of each other which also increases damages. If you can space a program out accordingly obviously your defects are reduced massively. *Do you think there are any ways of putting quality into a schedule? You said tradesmen cut corner, how can you minimise that?*

	Well quality is supposed to be there. Sometimes programs just don't allow for the higher level of quality. I mean if you've got stone bench tops, depending on the type of job of course, you will have a lot of problems with quality of the stone work. Due to it being more labour intensive to install apart from loading materials up the building. So program is key to all kinds of things defiantly as far as I'm concerned increases the amount of defect for every trade. *So basically just the duration is a main factor, but do you think defects will always occur?* Defects are always going to happen, but I mean the tighter the program the more defects will occur.

4.5.1.4 Contractor Question 4

Question 4	
Subcontractor 1 (Painting)	We have our allocations for each unit or each substrate that we work on so allocations are set by our employers. We are asked to meet them and most of them are within 10-15 to 30 minutes of time, so not over the top allocation of time is setup. The only problem we have iswhen we come into units to actually paint the unit we'll have mess on the floor, stuff not finished, setting required and just goes on and on. So to cut down on the time spent in the first half of the process, we need a little more time at first getting the unit prepared for paint so on and so forth, near the end of the job the defects would be not be as near as much as what the y are and would not take up so much time because we would have it done in the first instance and avoid damage you'd see form other trades on work we have already finished.

	Do you guys have a tick and flick process or inspections implemented? Yes we inspect their units before we go through and the supervisor on the floor might say that it isn't good enough to paint if necessary. Lots of the time it does not really mean much because the builder per say will demand the unit to be painted today. The painting supervisor or leading hand says it can't cause it's not ready. Although you are ordered to proceed so we paint the substrate we are given and then a day later we will be repainting the substrate because we've told them it wasn't sufficient. S wen virtually we go back over things not once but twice to paint a substrate we should visit one. So it's the time issue that cause the big problems. Trades before us aren't full filling their end of the bargain so we aren't able to fulfill ours. These creates a lot of defects such as patches, marks, dents and the list goes on and large. *I've done a case study of a 90 unit apartment complex and found and it shows that you as painters have the most defects. If you were to focus on marks on walls, is there any way you could reduce that defect in particular if you were given a program? Such as the sequence or structure of the scheduling.* It's a time thing because everyone is pushed. So the plumber can't fit off because something has to be done yesterday so he's bashing against the wall and putting a few dints in the wall. The electrician will come through and cut a hole in the wall in the wrong location. It's just an endless cycle, so thing will need to be patched up over and over. Once you start patching walls, you can't just patch walls, you are back for a repaint, and this goes for doors, architraves. Any substrate you paint and if it's damaged you really have to start the whole procedure all over again due to a little ding in the wall.

	Do think there are any strategies you could use such as locking entry doors after final paint? There are things like that procedure. Of course you lock the door and make everybody aware if they go into a unit and damage something there boss would be getting charged for they would be more careful and half the damage there is. So because no one's accountable for the damage and the painter has to cop it and have to go back because who knows who did it. We can't charge them because we don't know, who was it? What trade? We just don't know. Overall its great strategy but obviously doesn't reflect scheduling a whole lot. But it may be an idea to implement a line item showing when the unit is locked off, this may be a day after the final paint is applied, which will then need to be controlled very well for it to work I guess. But not a bad idea if to reduce defects in a unit. May even put in peoples mind that signing into units will catch them out if they cause a defect, introducing that care factor for instance. *So have you ever received a program from a builder and thought this won't work? Why is this the case and how could you make it more suitable to improve the quality of work fore say?* Yes, but this usually is to increase the time
Subcontractor 2 (Ceilings & Partitions)	So things that we use are QA forms, so when someone walks out of a room whether it's for framing, sheeting, setting, or marking out the walls, a process of walking through and checking to make sure everything is the way it's supposed to be. Time will fall down due to scheduling and not allow us to check over the work to get the right result.

	Is there anything the builder with their programs can change to benefit you and minimize defects? Changing the scheduling all the time doesn't help so sticking to a program we find that us being a company where we can bring on guys as we please, whoever that may be services or other but we are the ones that pull everyone back on track. So we bring on the extra guys and try and pump out the work to try and pull everyone back to bring back a program. In that instance, that puts a big strain on us to really pump out the work which then effects our quality and bring even more of a rush on the job which causes more defects in the end cause there's a fair bit of defects with patching, damage. You look at how many patches through lost wires
Subcontractor 3 (Joinery)	The best way to minimize defects is to find a good crew that you can trust to produce good quality work which you won't always get. Also you always have the same guys come in to do the same thing. It's ideal to keep the boys in the same room because some rooms are different types, if they go in the same room every time they'll get better and quicker at it. They know all the little things that are wrong. Also use templates for power point locations and cutouts or anything similar so they don't get them wrong to avoid mistakes. *Is there anything in your toolbox meetings or anything in the office that you use to improve the quality of your work?* There are QA's which are done by the fitters by ticking the list off. *The guys that install them also do their own QA'?* I'll come through and do the list and after I finish the room ill defect

	their work and fix it accordingly where I see necessary and if I have time to do so. *Is that prior to the builders defect period?* Even though the builders come through anyways, you get a fair bit a defects per unit. Obviously there are standard ones. The amount of joinery required particular rooms and the amount of time that these rooms sit there for and the amount of people that come in the rooms. People can bump stuff like doors, electricians are in there and install switches and power points which can create poor finished joinery and even people leaning on gables or opening cupboards without care (vanity doors) lead to doors being pulled off, and even shelves missing/getting thrown out afterwards. *Do you think there's a way you can stop these issues occurring?* No, you try to but you can't. You come in and appliances are ripped out from the kitchen and you don't know about it, leading to kickers being replaced (such as joinery kickers to dishwashers). Doors are scratched if they put them face down, people coming in and hitting it with their trestles, it doesn't matter how much protection you put on it. *Back to scheduling, what would you change if you could with a schedule that could minimize defects?* Less people in the room at a time so they don't work over the top of each other which makes it a lot easier. Give a bit more time per floor depending on how many rooms there are. *But how does it become worse if you have someone else in the room?*

	When you're installing joinery you have a room with one guy trying to fit it, you will then maybe have a tiling subcontractor trying to tile the bathroom floors which have wheelbarrows in there which makes it harder. This slows down workers trying to do a room and not making any money. They speed up, cut corners which creates defects. *Do you have any issues with floor preparation?* On this job we have heaps of dramas with the beds being done, so with vanities, we can't install vanities until the beds and waterproofing have been done. You need to push to get into the rooms and we can't finish the complete room and send people back to install. *So you were installing prior to tiling?* When you come into the room you should have the beds and bathroom done before you go into the room. *Do you think most cases it wasn't installed?* No, on one floor on a project with eleven units, we had every single kitchen installed and about four rooms and beds down only. *Do you think that makes your fitters speed up?* They get annoyed because they have to come back to the room to get all their tools where they fitted everything. Not hard to go back and do a vanity here and there or other rooms of the building. *Do you think that increases defects slightly?*

	Yes because they need to get it over and done with, it's all about money, got to make money. *So overall do you think your defects can be minimized through scheduling or is it more of a different issue?* Not really scheduling, only scheduling part about it is having the right amount of workers. The problem is if you get a certain amount of workers they need to keep that work pace up and to a sufficient standard, which goes for all trades.
Subcontractor 4 (Tiling)	It will all start with the first lot of QA. So before we get to a level, accepting any substrate whether that be walls or floors. So normally we would sign them off along with the builder saying it's acceptable for us to commence tiling. So if we do find any issue, the builder raises it with the appropriate subcontractor to have rectified. If it's one of those things that don't rectified, obviously it will create big dramas further down the track. We have a QA type system in place with the labourers, when they are loading up materials we assure they are loading up the correct tiles, quantities, and into the correct units due to various colour schemes that projects usually have. We have another small system before the tillers start to double check everything as well. *How does this process of QA go for tiling?* Well basically I provide them with a list of units with any type of variation or any changes to the unit. i provide marked up floor plans to labourers, this includes as mentioned before, quantities, colours, and locations, so when they load up they know exactly what's going into each unit. Then ultimately it's up to the tiling subcontractor to do their

	own QA but obviously each afternoon I'd stay back to see what has been done and inspect the work and bring up any issues the next morning in pre start meetings. I goes back to programming and how many other trades are working over the top of each other, all bunched up together because there's no breathing space at all. If one of the first tradesman trip up, it tends to affect all the proceeding trades. *Do you think if you guys were completing a unit without any other type trades entering the same time, would it improve the quality a lot?* Yes, it's not only defects it affects, it actually helps drag the program out. If you had a good run with a realistic program than that of an unrealistic program, you would tend to be quicker instead of being pushed out the door of each unit. *Do you find most jobs you are on have unrealistic programs?* Absolutely, but it's just the way construction is and it's the only way things get built in the time they do. I've defiantly seen some programs that are more realistic than others but having said that, you just got to deal with the cards you're dealt with sometimes. *If you were to change a schedule yourself, how would you reduce the number of defects you guys have prior to the builder's defects?* One of the issues I had on this project was because of program I had to keep increasing my work force. So through every stage of the job I had new people, new to the job and training them up again on what tiles and colour schemes go where. This just created a nightmare for me but ultimately these guys would come in and I'd be pushing them so hard from day one that I go inspect their work and they've laid the wrong

	tiles to two walls. So we would be pulling them off and redoing it. If to calculate the man hours and meters for the end of the week these guys have gone backwards in time and this is due to program. If the program wasn't so tight I would need thirty tillers on-site when we are nearing the end of the job where normally I'd be down to ten blokes. *If in the case a builder can't minimise duration, and there is a certain amount of time allowed for defects, could you eliminate builders defect and give you guys more time to do QA?* I've had all this time doing defects, but if I had time to do it the first time we wouldn't have so many. I mean we will always have them but on the last job I had, I had twenty one guys, we were virtually defect free as those guys were there from start to finish. And the program was nothing like we have here.

4.5.2 Subcontractor Summary

The following summary will provide brief notes as to what the subcontractors talked about. The summary below will help to discuss the main ideas and issues taken from the interview answers.

SUMMARY	**Subcontractor1 (Painting)**	**Subcontractor 2 (Ceilings & Partitions)**	**Subcontractor 3 (Joinery)**	**Subcontractor 4 (Tiling)**
Q1	Poor substrate and damages from other trades	poor setting, sanding, and pin holes	Excess glue, chipped joinery, damages	Chipped tiles, missing grout
Q2	Poor substrate and damages by	poor setting, sanding, and pin	Replacement of panels/gables	Replacement of membranes or

	other trades	holes		chipped tiles
Q3	Increasing duration or implementation of QA line items	Increasing duration	Not a scheduling issue really for joinery items, just human error.	Increasing duration
Q4	Introduce care factor by sign in keying system. Better quality substrate handover. More time for QA	More realistic program, schedules are being updated frequently	Does not agree scheduling can minimise defects unless duration is increased	More time for QA, increase care factor from other trades

4.6 Discussions

A comparison between results will need to be discussed in order to implement a strategy or notion that could possibly align with the literature findings. In doing so, the responses from real professionals can be compared with literature and used to identify if a strategy can be used and tested on some common defects. Defects have a high frequency occurrence from what was mentioned from all participants and also supported by Shirkavand (2016) also. Following will be a discussion of results for both contractors and subcontractors which will help identify solutions to the defect issue.

4.6.1 Contractor Results

With the results found and discussions had, it can now be determined if a quality led schedule can minimise defects. Firstly from the contractor's point of view, an analysis was undertaken to see if their answers were beneficial and whether this reflected anything found in the literature or case study results. There on, this was them done for the subcontractor's point of view, being the painters, ceilings and partitions, joinery, and

tiling. Following will be a discussion of results between all contractors on each individual question asked to analyse the data found.

4.6.1.1 Contractor Question One Results

After interviewing the representatives from builder/contractors there were very similar responses. In summary, the most common defects the contractors thought of were painting touch ups, quality of setting, incomplete works, cleanliness of the units, and patching requirements. All these seemed quite reasonable based on the subcontractor results. In regards to the aim and objective for the research project, it was important to identify the most problematic of the common defects which is discussed in question two of the contractor's interview.

4.6.1.2 Contractor Question Two Results

The most problematic of the defects occurring was the struggle to keep units clean, maintain the final coat of paint, and to avoid damaging installed joinery such as water residue being left on vanity tops too long which may lead to replacement and rework for fit off trades. Stated from contractor one, "with cleaning items, once a cleaner goes through during our construction process with other trades doing defects in the units, typically they do leave rubbish behind them and being a foreman you can't be in every place at once to mitigate this issue. So keeping the units clean to avoid rubbish damaging the units would be ideal". Although does not seem like a big deal, the project manager thought very strongly of clean units due to the fact that rubbish would cause damage to walls and floor coverings generally.

4.6.1.3 Contractor Question Three Results

Question three discussion focused very much on the aim of the research project. Both contractors discussed the standard sequences in place and struggled to come to any solution for integrating quality into scheduling to minimise these defects. Contractor two mentions "But as I said these small procedures do help and do reduce defects to some degree, although you will always have defects throughout the construction process. Not one job is going to be defect free but you do hear people talk about defect free project but they do have defect processes which they achieve to close out defects prior to the end of the job". Saying this, the small procedures or rules would include the pre start meetings,

discussions with trades, look ahead ahead programs and more, although in turn the interviews do not come to a solid solution regarding quality led scheduling to achieve minimal defects. Rules and strategies form the contractors include pre start meetings, sign off and checklist before commencement of the next trade, and of course extended durations which is deemed not a reasonable solution in the construction industry.

4.6.1.4 Contractor Question Four Results

Now the most common defects according to the case study was provided to contractors for review and comments. Contractors briefly discussed the most problematic defects occurring with painting, ceilings and partitions, joinery, and tiling. The responses were very similar to that of question one. For painting, the most problematic would seem to be related to ceilings and partitions, where patching walls would be required quite frequently and this process of rectification takes time and is costly. Joinery again had the biggest impact when panels were needing to replaced due to extensive damage. This leads to more defects by fixing just one, such as damaging silicone or even finished walls (damaging plaster beneath paint). For tiling, this was a minimal occurrence of defects in comparison to painting and ceilings and partitions. Tiling was usually chipped tiles or damaged substrates, which would have tiles being replaced and wasting more duration provided by the builder.

4.6.1.5 Contractor Question Five Results

Lastly, even though the contractors both seemed to think there was not much that can be done to minimise defects through improvement of the schedule itself, they did have rules and strategies that may be beneficial in minimising defects. Following are a few good solutions from discussions that were believed to be quite helpful on projects the builders were involved with throughout their careers;

1. Keying system that minimises traffic through units
2. More attention to QA procedures
3. Duration increases (minimising the length of defect periods and using that earlier on for better QA)
4. Joinery install before tiles which does not always occur

4.6.2 Subcontractor Results

Defects that are most common have already been identified through supported literature. In addition, defects that are seen as common from the professional interviews will be considered for a more in depth discussion of results. With integration of quality, it will be ideal to review each individuals company scheduling processes for comparison and to identify improvement is possible.

4.6.2.1 Subcontractor Question One Results

After in depth discussions on what defects were most common within their trade, the results seemed to match the case study quite well. For Tiling, being the fourth most common according to the case study, the defects that most common were chipped tiles, gaps in grout, and general damages. The tiling subcontractor was not that worried about the amount of defects caused by them due to it not being a great impact on time and cost although would be beneficial to minimise them. Joinery Subcontractors stated that their most common defects found during the job was chipped joinery, missing screw caps, and excess glue. These defects were not so problematic although the quantity was high and very time consuming because of it. Ceiling & Partition subcontractor's most common defects weredamage from other trades which would be poor setting, sanding, and pin holes. After that would be missing hardware or sundry items in units. Although these may seem quite simple the damage to walls can have a big impact on scheduling. Lastly for the painters, there most common defects from the interviews was patch and paint, marks on walls, and poor finishes to substrate. These defects which are explained in question two discussions are very problematic.

4.6.2.2 Subcontractor Question Two Results

Question two being to identify the most problematic defects helps to understand what defects really need attention and if resolved can create a bigger and better solution. For tiling, as quoted by the subcontractor "damages to tiles especially in wet areas where membranes and everything underneath on your substrates. Obviously you go to replace the damage tiles therefore sometime the area grows because you have to increase the waterproof lap back to the original waterproofing so basically can turn into one big night mare". A good example of the amount of rectification involved which would evidently lead to more cost and time assumed out of a scheduled duration. For joinery, although not

a most common defect was the replacement of panels or gables. This means damaging silicone, caulking, and surrounding joinery all just to replace one panel in most cases. Hence a very critical defect to ensure doesn't occur. Ceilings and partitions and painters would be the most crucial and problematic of them all due to the frequency and impact they both have on each other. For example, the ceilings and partition subcontractor and painters agree that if the substrate is handed over to the painter with poor quality the defects usually are identified although due to time restraints, the quality checks in place are poor and therefore lead to finished and painted walls being skimmed, patched, and repainted again. This in turn builds up to a lengthy process and with multiple occurrences will affect programming and scheduling.

4.6.2.3 Subcontractor Question Three Results

No with better scheduling, question three has the aim of improving a schedule to minimise defects in particular, in particular the most problematic and most common. Surprisingly no subcontractor referred to anything about look-ahead programs nor did location base scheduling get mentioned. With this in mind, it may have been beneficial to see if this was ever utilised in their industry. Moreover, all subcontractors for obvious reasons said that more time would allow for more quality assurance and better products and finishes being handed over to the next trade. In the end this would improve a schedule to minimise defects although is not a liable solution due to time constraints given by builders, which all trades mentioned soon after. In particular, painter talks about if the plasters were to handover a unit with a quality standard, amount of defects would reduce dramatically. Furthermore, if be forced to paint in order to meet schedule and end up repainting anyway, it has defeated the purpose and increased the duration in the end of scheduled time set in the first place. Therefore if to reduce the defect period at the start, it may be an idea to increase the trade works by a means of half a day or even a day if possible to sign of units/apartments properly and to a standard that is acceptable to th painter and builder. Ensuring the builder has the right mindset on quality with time and not just rushing the job to meet deadlines earlier.

4.6.2.4 Subcontractor Question Four Results

This question was to find ways that you can minimise these defects through better ways of working or any strategies, rules, templates, blueprints, standard procedures that could be implemented. Although not all subcontractors had helpful responses, some did. The painter spoke about the implementation of a keying system which is very common in the industry not integrated into a schedule. He states "It may be an idea to implement a line item showing when the unit or floor is locked off, this may be a day after the final paint is applied, which will then need to be controlled very well for it to work I guess. But not a bad idea if to reduce defects in a unit. This may even put into people's minds that signing into units will catch them out if they cause a defect, introducing that care factor". I think this sort of strategy may be very beneficial to painting defects, where in most cases painters are called back to rectify issues caused by others at their own cost due to careless behavior from other trades.

4.6.3 Case Study Results

The case study results which was previously discussed in section 4.2, was a big effort in attaining the data collection and benefitted on the material used for the interviews. Due to the fact the last unit that was defected on the case study project was late 2016, the data collection is not out dated and deemed fairly accurate across projects in Brisbane according to the participants involved in the interviews. Again, taken from section 4.2, the below table has been taken down to the trades that cause most common defects;

Table 4.6.3 – Most Common Defects and Trades

Trade	Defect Quantity	No. of Units	Avg. Defects / Unit
Painting	**5702**	**90**	**63.4**
Ceilings & Partitions	**2809**	**90**	**31.2**
Joinery	**2619**	**90**	**29.1**
Tiling	**1161**	**90**	**12.9**

Now according to these results in table 4.6.3, it would be ideal to focus on the painting, ceilings and operations. Hence from discussions, to improve a schedule, ensuring the quality assurance factor is improved may help. This may be to increase duration if

possible to both these trades only. Being to increase the time allowed for sheeting and setting for ceilings and partitions, then not so much increase painting time but reduce the amount of traffic in units by use of a keying system that is controlled well by on-site foreman.

4.7 Results Analysis

From the discussion there can be a few things taken into account to minimise defects. In regards to the aim and objectives, being to minimise defects through better scheduling with quality, the discussions above do provide a some helpful strategies although do not provide one solution that minimises defects as a whole. Strategies that were suggested that seemed very beneficial to reducing mainly the painting defects was the keying system mentioned by the painter and contractor one. This strategy was to have a keying system that would lock subcontractors out of the unit after the final coat of paint was applied. The issue though would be controlling who needs to enter what unit to fix defects are finish works required by other trades. This will create a care factor for tradesman entering the unit if they sign in, being full aware that if major defects are caused whilst in the unit, they will be held responsible and accountable for any additional costs.

Another rule was to have wet trades before dry trades, except in the case of joinery and tiling. This meaning that joinery items should be installed first due to the difficulty of having joinery come out of the factory and having to fit around tile joins and tile floor falls would be very difficult and margin for error would be quite high. Keeping in mind this is a general practice used in the industry so therefore not a successful rule found in this research project.

For scheduling, being the main focus, the only major change would be the duration factor. As all contractors and subcontractors were asked the question whether there was any opportunity to adjust the sequence on a schedule and all cam e back with no changes. The conclusions of the results basically come down to the quality assurance and checks taken place, where there should be more care involved. One other factor mentioned y

subcontractors mainly was to make scheduling more realistic in regards to durations and time frames, although full aware that it is the builders job to tighten a schedule as much as possible and seems achievable.

Chapter 5: Conclusion

5.1 Introduction

This research project has sought to investigate the integration of quality into scheduling in order to minimize defects in the construction industry, focusing primarily on the finishing trades. In order to achieve the project aim it was necessary to achieve the following:

1. Understand relevant literature for strategies that minimise defects through quality management in residential construction during the finishing trade stages.
2. Develop a strategy or blue print that can be implemented and successful in minimising defects in residential construction.
3. Use the guideline and literature research in section A & B to establish the strategy's relevance for minimising defects in the construction industry.

5.2 Discussion

To get a better understanding of relevant literature, the literature review was quite extensive and found to be very difficult to find research integrating all three aspects of defects, scheduling, and quality. From the literature review, key factors were outlined and discussed in order to understand the all three aspects of the research topic and gain knowledge in integration of quality into scheduling. From the literature review, common defects were identified and solutions to minimise these were found to an extent. Scheduling types and improvements were also discussed along with scheduling principles to try and improve the quality of work, ultimately to reduce defects on-site.

The literature review unfortunately was limited to the focus of the research topic. This meaning that there was not much available in terms of finding a quick solution to the problem of defects relative to scheduling. Hence, it was found that the most common literature was the types of scheduling which was looked into, aiming to see whether they

could reduce defects from occurring. The literature review then covered multiple approaches to rules and strategies to improve a schedule. This information was not a great asset due to the relevance of the most common defects found from the case study occurring due to other reasons other than scheduling in most cases. This was also supported in the interviews undertaken.

The methodology procedure was very interesting and provided the research with very rich information helpful towards the real issues of common defects and the chances of improving a schedule with quality to do so. Firstly with the case study, most common defects were identified and fortunately was very compatible and similar to literature available. Therefore the case study results assisted in the interview questioning to gather insights on those defects that were found to be more common. As mentioned in the results analysis section 4.7, there were minimal quality and changes to scheduling that could minimise defects although found that there were some strategies, rules, and procedures discussed about that may minimise defects.

In summary, contractors and subcontractors as a whole were not so supportive of the idea that scheduling could minimise defects with quality implementation unless the duration for their respective trade or just in general could be increased. Keeping mind each participant did provide helpful guidance and data that lead towards other types of strategies that could be implemented for further work or recommendations which will be discussed in section 5.3 to follow.

5.3 Further work / Recommendations

While the industry of construction faces defects every day and is deemed to always incur them, the idea of improving a schedule besides increasing the duration is quite difficult. For further research and work based on the results found in this research project, it would be ideal to look further into types of strategies, rules, or procedures that could be improved or created to enhance the quality of workmanship to ultimately minimise defects. Keeping in mind it would be beneficial to focus primarily on the most common defects and what trades were liable.

5.4 Limitations

Limitations for this research project were very minimal although were present

1. List of top ten defects according to QBCC does not reflect high-rise apartment complexes only. Hence the need to eliminate defects that are irrelevant
2. Case study results are limited to a particular project located in Brisbane
3. Both the case study and QBCC results are quite accurate although the projects used have their own design issues which affect the types of defects found

5.5 Future research

To further this research topic, there is the opportunity to look into the rules and strategies suggested and found from the interviewees. The case study results may be useful for further common defect research also. In addition it would be worth looking further into improving not only scheduling but specific types such as look ahead programs that are utilized on many construction sites.

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Appendices

Appendix A – Project Specification

ENG4111/4112 Research Project
Project Specification

For: Austin Tippett-Whiteman

Title: Strategies for minimising defects by integrating scheduling with quality

Major: Construction Management

Supervisors: Vasantha Abeysekera

Enrolment: ENG4111 – EXT S1, 2016 ENG4112 – EXT S2, 2016

Project Aim: To develop strategies for minimising defects by integrating scheduling with quality.

Programme: Issue B, 26 April 2016

1. Identify strategies that have been proposed by others in how scheduling can minimise defects. Identify if possible to sequence finishing stage activities in multi-stage residential construction project in a certain way that will minimise defects suggesting that it would be possible to develop a blue-print which if adopted would minimise defects.

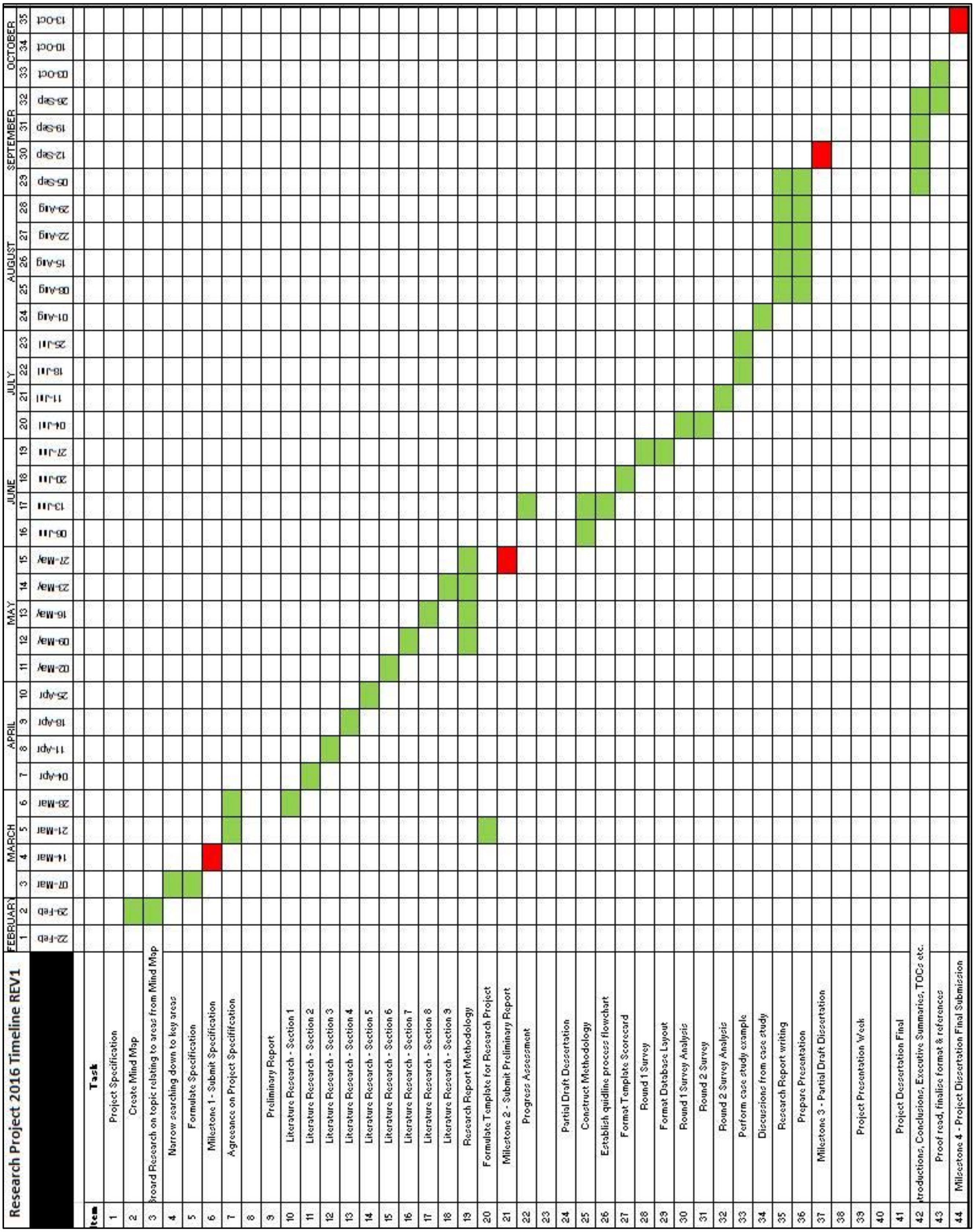
2. Investigate the nature of such a schedule (through published literature including the notion whether such a schedule can be developed, and if so, labelling this initiative as a 'quality led schedule'. Focus on a typical unit within a multi-story residential construction project and developing a schedule for such a project; establish features of a schedule in the first place, and use these features to develop a schedule that has the power to minimise/eliminate defects.

3. Develop such a schedule (which has the potential to minimise defects) and discuss the features of this schedule with experienced construction managers and come up with a hybrid/advanced schedule (or features) with a view to developing a schedule that would minimise defects.

4. Having 'designed'/'synthesised' such a schedule (or its broad features/elements), examine a past project and investigate whether the defects in this project can be explained through the lack of compliance with the 'prototype plan' developed.

5. Confirm/reject the strategy that defects can be minimised/eliminated by following a quality-led schedule (or say a blue-print schedule).

Appendix B – Timeline



Appendix C – Ethics Approval Letter

OFFICE OF RESEARCH
Human Research Ethics Committee
PHONE +61 7 4687 5703| FAX +61 7 4631 5555
EMAIL ethics@usq.edu.au

UNIVERSITY OF SOUTHERN QUEENSLAND AUSTRALIA

20 September 2016

Mr Austin Tippett-Whiteman
22 Dellow Street
Acacia Ridge
Brisbane Qld 4110

Dear Austin

The USQ Human Research Ethics Committee has recently reviewed your responses to the conditions placed upon the ethical approval for the project outlined below. Your proposal is now deemed to meet the requirements of the *National Statement on Ethical Conduct in Human Research (2007)* and full ethical approval has been granted.

Approval No.	**H16REA223**
Project Title	Integrating scheduling with quality to minimise defects in construction
Approval date	20 September 2016
Expiry date	20 September 2017
HREC Decision	**Approved**

The standard conditions of this approval are:

(a) conduct the project strictly in accordance with the proposal submitted and granted ethics approval, including any amendments made to the proposal required by the HREC
(b) advise (email: ethics@usq.edu.au) immediately of any complaints or other issues in relation to the project which may warrant review of the ethical approval of the project
(c) make submission for approval of amendments to the approved project before implementing such changes
(d) provide a 'progress report' for every year of approval
(e) provide a 'final report' when the project is complete
(f) advise in writing if the project has been discontinued, using a 'final report'

For (c) to (f) forms are available on the USQ ethics website:

http://www.usq.edu.au/research/support-development/research-services/research-integrity-ethics/human/forms

Please note that failure to comply with the conditions of approval and the *National Statement (2007)* may result in withdrawal of approval for the project.

You may now commence your project. I wish you all the best for the conduct of the project.

Samantha Davis
Ethics Officer

Copies to: u1046417@umail.usq.edu.au

Appendix D – Interview Consent Forms

University of Southern Queensland

UNIVERSITY OF SOUTHERN QUEENSLAND AUSTRALIA

Consent Form for USQ Research Project Interview

Project Details

Title of Project: Integrating scheduling with quality to minimise defects in construction

Human Research Ethics Approval Number: H16REA223

Research Team Contact Details

Principal Investigator Details
Mr. Austin Tippett-Whiteman
Email: aus.j.w@hotmail.com
Mobile: 0451263639

Supervisor Details
Dr Vasantha Abeysekera
Email: Vasantha.Abeysekera@usq.edu.au
Telephone: (07) 34704152

Statement of Consent

By signing below, you are indicating that you:

- Have read and understood the information document regarding this project.
- Have had any questions answered to your satisfaction.
- Understand that if you have any additional questions you can contact the research team.
- Understand that you are free to withdraw at any time, without comment or penalty.
- Understand that you can contact the University of Southern Queensland Ethics Coordinator on (07) 4631 2690 or email ethics@usq.edu.au if you do have any concern or complaint about the ethical conduct of this project.
- Understand that the interview will be audio recorded.
- Understand that I will not be provided with a copy of the transcript of the interview for my perusal and endorsement prior to inclusion of this data in the project.
- Are over 18 years of age.
- Understand any data collected may be used in future research.
- Agree to participate in the project.

Participant Name: Ryan Wall.

Participant Signature:

Date: 25.09.16

Please return this sheet to a Research Team member prior to undertaking the questionnaire.

Page 1 of 1

University of Southern Queensland

Consent Form for USQ Research Project Interview

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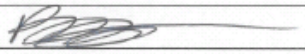
Participant Name	BEN BORSHT
Participant Signature	
Date	26/09/16.

Please return this sheet to a Research Team member prior to undertaking the questionnaire.

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Mobile: 0451263639

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Participant Name	Scott Clements.
Participant Signature	S. Clements
Date	24-9-16.

Please return this sheet to a Research Team member prior to undertaking the questionnaire.

University of Southern Queensland

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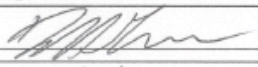
Participant Name	Brett Moore
Participant Signature	
Date	25/9/16

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University of Southern Queensland

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- Understand any data collected may be used in future research.
- Agree to participate in the project.

Participant Name	ADAM ROBERTS
Participant Signature	
Date	24/9/2016

Please return this sheet to a Research Team member prior to undertaking the questionnaire.

University of Southern Queensland

Consent Form for USQ Research Project Interview

Project Details

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Dr Vasantha Abeysekera
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- Are over 18 years of age.
- Understand any data collected may be used in future research.
- Agree to participate in the project.

Participant Name	CLINT PATMORE
Participant Signature	
Date	24-9-16

Please return this sheet to a Research Team member prior to undertaking the questionnaire.

Appendix E – Information Sheet

University of Southern Queensland

Participant Information for USQ Research Project Interview

Project Details

Title of Project:	Integrating scheduling with quality to minimise defects in construction
Human Research Ethics Approval Number:	H16REA223

Research Team Contact Details

Principal Investigator Details

Mr Austin Tippett-Whiteman
Email: U1046417@usq.edu.au
Mobile: 0451263639

Supervisor Details

Dr Vasantha Abeysekera
Email: Vasantha.Abeysekera@usq.edu.au
Telephone: (07) 34704152

Description

To successfully identify strategies for minimising defects by integrating scheduling with quality (focusing mainly on finishing stage trades), a methodology will need to be developed in order to provide a procedure at which this can be achieved. Accordingly, the following procedure will be adopted:

Step 1: A case study of a multi-storey residential apartment complex as a participant observer (as I am currently working on a multi-storey residential project) with the main intention of ascertaining the type and frequency of defects at the finishing stage, and then ascertaining whether these defects could have been excluded by developing strategies (rules, procedures etc) for sequencing of related work so as to avoid these defects. Interviews will be conducted with in-house construction managers and also related subcontractors using an interview guide.

Step 2: A semi-structured interview with selected participants on how defects could be minimised by integrating schedule (sequence activities, resourcing, templates for scheduling, etc.). These interviews will also be used to understand how defects identified by QBCC (vide top ton defects) could be avoided through correct sequencing of activities and other strategies.

Participation

Your participation will involve an interview for approximately 30 minutes of your time.

Questions will include:

"What are the most common defects in high-rise apartment complex projects during the finishing stages...?"

"According to the QBCC the most common defects are... Do you believe this is the case for high-rise residential apartment projects...?"

"Is there a way to minimise defects through scheduling with integration of quality ...?"

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. If you do wish to withdraw from this project, please contact the Research Team (contact details at the top of this form). Interview will be audio recorded.

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

Expected Benefits

The project will prove useful to companies in the high-rise residential construction industry as well as clients building a new project and also to the future professionals wishing to further research in this area. The results of the case study and QBCC results will be compared and analysed in order to possibly produce a blue print or a set of rules that should be adopted based on the results received. The main benefit would be to create the blue-print or set of rules if achievable so to minimise defects in the construction process.

Risks

There are no anticipated risks beyond normal day-to-day living associated with your participation in this project.

Privacy and Confidentiality

All comments and responses will be treated confidentially unless required by law.

Any data collected as a part of this project will be stored securely as per University of Southern Queensland's Research Data Management policy.

Participants can request a summary of the research results by sending an email to the principal investigator provided on this information sheet.

Any data collected may be used in future research activities.

Consent to Participate

Signing the consent form provided for the interview is accepted as an indication of your consent to participate in this project.

Questions or Further Information about the Project

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 Regarding the Conduct of the Project

If you have any concerns or complaints about the ethical conduct of the project you may contact the University of Southern Queensland Ethics Coordinator on (07) 4631 2690 or email ethics@usq.edu.au. The Ethics Coordinator is not connected with the research project and can facilitate a resolution to your concern in an unbiased manner.

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