THE MAIN FACTORS THAT PROMOTE SUCCESSFUL INNOVATION WITH PRODUCTIVITY WITHIN THE CONSTRUCTION INDUSTRY IN AUSTRALIA: THE PROJECT MANAGER'S PERCEPTION – AN ANALYSIS

A thesis submitted by

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ABSTRACT

The problem of poor productivity in the construction industry is a worldwide phenomenon. The issue is complex as productivity is inconsistent between countries, projects, and even separate sections of the same project. This study has reviewed construction productivity in Australia by surveying Australian project managers using the proven relative importance index approach, to obtain their views on the importance of factors affecting construction productivity. This study also triangulates through validating the main factors from this research using a group of construction industry experts in a Delphi survey. In addition, this research has also sought, from this expert group, information on their views of the likely frequency of occurrence of these factors, plus useful qualitative information with respect to construction productivity. The methodology employed is a significant contribution to construction productivity knowledge in Australia and is different from the previously used economics-based factor analysis approach.

The purpose of the study was to assess and promote productivity in the Australian construction industry. Improving productivity in the construction industry will improve the national income and reduce unemployment.

The specific objectives of the study were:

- To classify the factors that currently influence productivity in the construction industry in Australia and to ascertain the most significant factors contributing to poor productivity.
- To determine the significant key performance indicators of construction productivity in Australia.
- To classify the critical success factors which are most authoritative in achieving productivity success
- To verify (using an expert group) the essential aspects detracting from success in productivity in the Australian construction industry and to evaluate the degree of agreement/disagreement among the project managers.
- To review the theory through validating the relationships with the ratings of

experts, who included people from academia, consultancy, public works, and contracting.

The group of project managers engaged in the construction industry in Australia identified in the questionnaire survey that issues relating to shortage of building materials, inadequate drawings, shortage of tools and machinery, rework, changes in orders, equipment disruption causing delays to the work schedule, and inefficient supervisors were the major causes of production inefficiency.

The research has confirmed the existence of construction productivity problems. The shortage of management support and the use of inexperienced staff have been found to be the most significant obstructions to improvements in productivity. In the project management area, early preparation and arrangements for projects have been found the most likely to boost productivity regardless of company size. In the case of issues associated with work sites, improved administration, avoidance of rework, improvement of communication and provision of suitable equipment are likely to be the most promising factors to improve productivity.

CERTIFICATION OF THESIS

This thesis is entirely the work of Rami Hughes except where otherwise acknowledged. The work is original and has not previously been submitted for any other award, except where acknowledged.

Principal Supervisor: Associate Professor Dr David Stuart Thorpe

Associate Supervisor: Professor Ron Ayers

Student and supervisors signatures of endorsement are held at USQ.

DEDICATION

This research is lovingly dedicated to my late parents (may Allah grant them mercy), who instilled in me the respect for higher education.

In addition, to my sincere daughter, Merriam Rami Hughes, for her help, patience and support. Wishing her all the best to realise her goals and dreams. My anticipation is to spark her to pursue her civil engineering studies and lead her to a bright future and a successful life.

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CHAPTER ONE
RESEARCH INTRODUCTION AND OBJECTIVES

1.1 RESEARCH INTRODUCTION

The construction industry performs a large part in developing and accomplishing economic stability in many countries. The construction industry is one of the biggest industries and supplies almost 10% of the gross national product (GNP) in modern nations. The construction industry is complex because it consists of a huge number of participating groups: customers, contractors, consultant engineers, stakeholders, shareholders, and regulators. The accomplishments of the building/construction business are influenced by the national economy (Navon 2005).

The building/construction industry is exposed to high potential risk and uncertainty. These uncertainties, if executed, result in lower productivity or project setbacks or collapse, and require awareness of the business in relation to budgets, periods, and standards of the competition. There are a large number of construction firms; it is possible to start a unique construction company if the capital becomes available. Yet, without good administration and professional competence, the probability of disorganization and low productivity is raised and this represents one of the risk factors for company failure.

An investigation suitable for relevant contemporary research demonstrates that construction projects are often concluded with enormous cost, delayed timetables, and quality concerns. Productivity problems are designated as exceeding of time beyond the deadline date either stated in the arrangement or set among the project’s aims for finishing of the project. Productivity problems in the building and construction industry can create failure or adversely influence a few or all of the project groups. The results of all these problems include time overruns, expense overruns, conflicts, mediation, dispute, and desertion. Some researches precisely investigated productivity problems and tried to classify the reasons and create the way to eliminate it (Chancellor 2015; Assaf & Al-Hajji 2006; Bettaineh 2002; Al-Momani 2000; Baldwin & Manthel 1971; Chan & Kumaraswamy 2002; Frimpong, Oluwoye & Crawford, 2003; Kaming et al. 1997a; Odeh, Odeyinka & Yusuf 1997; Ogunlana & Prumkuntong 1996).

For the last forty years, many researchers have examined aspects which help the profitable achievement of these projects, especially those which influence the project achieving more than others (Holt & Gary 2014; Baker, Murphy & Fisher 1988; Cleland & King 1983; Locke 1984; Morris & Hough 1987; Pinto & Selvin 1987). Critical success aspects thus are, for any industry, the restricted figure of areas in which outcomes, if they are adequate, will guarantee competitive efficiency (Rockart 1979).

The idea of the achievement factors in building/construction productivity can, according to a number of investigators, be assessed exclusively when these evaluations are sufficiently outlined (Enshassi et al. 2014; Baker, Murphy & Fisher 1988; Morris & Hough 1987, Pinto & Slevin 1987; Turner & Muller 2003). For most projects, the assessment includes the usual restraints of schedule, budget, and characteristics factors. Ashley and Bonner (1987) defined project achievement as conclusion exceptional than anticipated or usually noticed in terms of budget, time, characteristics, security, and participant contentment. Early investigation to determine records of demanding achievement aspects was initiated by Ashley and Bonner (1987) who established which aspects were significant for successfully finishing construction projects.

Investigations into aspects detracting from achievement began in 1967, and illustrate the advancement of data on these detracting aspects established in practical and hypothetical research (Baker, Murphy & Fisher 1988; Cleland & King 1983; Pinto & Kharbanda 1995; Pinto & Slevin 1987; Tukel & Rom 1995; Walid & Oya 1996).

This research is extending this previous research by examining the factors classified. This work investigates success factors in a unified pattern to decide which critical success factors are most significant in averting critical productivity obstacles. This will help organizations working in construction projects as the groundwork on which such an approach could prevent construction productivity complications. The study is focusing on productivity in building and construction projects in Australia, which were evaluated for obstacles to productivity.

First, the aspects that detract from achievement aspects are determined, and the chances of developing project productivity through government and private classifications of Australian building/construction projects are examined. The study examines the importance and appropriateness of these projects for the national building business, with its unique experience, bureaucratic arrangements, and other matters. In the Australian construction industry, project conduct is generally calculated according to time, cost, and quality of works, and these are noted as the iron triangle (Enshassi et al. 2014; Atkinson 1999).

In the advanced, developed and developing countries, the building/construction industry plays a great part in the national economy by contributing generously to gross domestic product (GDP), hiring a great number of construction workers and tradespeople; the construction industry is considered to comprise fifty per cent of the essential establishment and collaborates strongly with other sections of the economy (Megha & Rajiv 2013; Hillebrandt 1985). In addition, the construction industry contributes a great increase in the national income with the economic evolution recently happening in Australia.

In construction business, three groups are involved, the proprietor, the consultant engineer, and the contractor. The connections among these groups are antagonistic, as each group's goal disagrees with the other groups' needs. For instance, the proprietors want their project to be of highest quality and completed at minimum cost, but this will minimise the margins of the construction company charged with carrying out the project. The consultant engineer requires the project to be free of harm, but this is likely to create for both the construction company and the proprietor more cost. Finally, the labourers hired by the construction company want good wages, which, again, would raise the cost of the project. Thus, the relationship between these parties can contribute to low productivity or project failure. To mitigate these factors, project management companies are used.

Managers are not always able to cope with the dynamic nature of projects, where decisions have to be made fast, and planning and control have to be very tight (Fewings 2005). Project management has, therefore, been developing since the mid-1940s (Fewings 2005) as a methodology that can be applied to intensive periods of work that have a specific objective. Project management can thus be isolated from general management, expenditure can be ring-fenced, and the synergy of a team engaged. The productive achievement of the project administrator is the greatest aspect influencing the achievement of project results (Hu & Liu 2016; Powell & Skitmore 2005).

Nevertheless, when clients are using independent project management or surveying companies to run construction projects, a number of problems can arise. The fundamental obstacles faced are relationship-based, whether in the relationships with other professionals on the project team or with the client companies in the construction industry. The view that project management companies take of their roles and of their experiences in managing construction, projects can provide suggestions for improving relationships. The problems faced by construction management companies are likely to be global and, therefore, any solutions suggested may be able to be applied to other countries.

Nowadays, hiring an individual project management company or quantity surveying company to handle construction projects has become an accepted process globally. Although the common arrangement of hiring an architect to handle the design and run the construction project has remained in use, recent times have seen the growth of many project quantity surveying firms and project management facilities around the world – in the meantime, project management firms have been increasing rapidly, especially in the past few decades. In Australia, the quantity surveying occupations have taken up project management over a long period. Indeed, earlier research by (Lamb 2004) stated that two-thirds of quantity surveying companies in Australia provide project management to their project owners or proprietors/clients as a key part of their main services.

The advantage to a client of construction management or project management companies is the efficient completion of a given project on schedule within a cost estimated and to high specifications. On the other hand, the disadvantage is an increase in management costs. Although most construction companies nowadays are using project management companies, there are still many factors affecting and hindering project performance and productivity.

For the sake of improving productivity, research into the projects influencing productivity is important. Making use of those projects that undoubtedly influence the productivity and eradicating the aspects which have an adverse outcome will greatly enhance construction productivity. If all influencing aspects are noted, it could be possible to predict the value of the productivity (Lima 1995).

Many studies have previously examined the projects, which influence labour productivity. A few investigators (Holt 2014; Kaming et al. 1998; Olomolaiye, Jayewardene & Harris 1998; Rojas & Aramvareekul 2003a; Teicholz, Goodrum & Haas 2001) have examined the aspects influencing construction productivity. A number of investigators have also examined the aspects that affect workers' productivity (Hu & Liu 2016; Hanna et al. 2005; Kaming et al. 1998; Lema 1995; Lim & Alum 1995; Makulsawatudom, Emsley & Sinthawanarong 2004; Minchin Jr. et al. 2003; Olomolaiye, Jayewardene & Harris 1998; Teicholz, Goodrum & Haas 2001; Thomas et al. 1985; Wachira 1999). Projecting one aspect (applying, for example, labour model, tangible component, building/construction procedures and design necessity) and anticipation approaches are procedures for determining construction workers' productivity (Thomas et al. 1990). Many attempts have been made regarding the ranking of factors affecting the Australian construction productivity. A human development report in 1995 stated that in common circumstances, two main aspects influence construction site workers' productivity, namely, managerial progression and execution progression. Managerial progression includes tangible elements of the project, specs necessities, drawing particulars, and so forth. Execution progression has connection to the work surroundings.

1.2 EMPHASES OF THE RESEARCH

The investigator's own knowledge over many years with the building/construction productivity problems in the industry in Australia is largely in alignment with the problems regularly classified in the research. Frequently construction productivity problems include the following: project delivery time, where the project is not finished within the scheduled time; poor quality standard; cost overruns; usage of undefined building components; unskilled trades; transferring the projects after awarded to sub-contractors; improbable joint partnership; project cancellation or collapses; equipment poor maintenance and breakdown; and poor safety on the site, for example human and equipment accidents.

Whether they are aware of it or not, proprietors demonstrate comparable deficiencies, to some degree, either because of inadequate experience or due to insufficient investigation. Proprietors have obstacles starting with the design aspects; some large projects planned and designed overseas could fail because the designers did not visit the construction sites in Australia to explore the site conditions and suitability for their drawings.

All these obstacles have adverse impacts on the groups involved in the project, the results may be significant losses for all involved, also it will lead to a decrease in site safety, and all these obstacles will have very negative impacts on the country in general. In consideration of these limits, this dissertation has examined these obstacles and concentrates on the critical factors hindering construction productivity and the important aspects that could assist to prevent or eliminate them in the building/construction industry and if possible make significant improvements in construction productivity.

1.3 OBJECTIVES OF THE STUDY

The factors influencing construction productivity in Australia are obstacles, just as in several other countries in the world such as Nigeria (Muhwezi, Acai & Otim 2014; Rojas & Aramvareekul 2003b). In addition, aspects influencing building/ construction work rate are exceptionally consistent and may change from one country to another, from a project to another and even through the same project, depending on circumstances (Olomolaiye, Wahab & Price 1987).

The aim of this research is to confirm or to gain new insights into the perceptions, from the project manager’s perspective, of the aspects influencing building/construction productivity in Australia and to analyse the local factors which affect productivity. This has been done in a number of countries. This particular type of research has also been done in Australia and in particular in Queensland.

One of the objectives of this study is to enhance productivity in the building business in Australia. The goals of this research are:

1) To pinpoint the hindering aspects that presently continue in the construction/ building business in Australia by uncovering the best practices prevailing and the complications influencing productivity achievement.
2) To decide the most compelling key barometer of building/construction productivity in Australia.
3) To classify the negative achievement aspects which are most significant in hindering productivity success.
4) To analyse, using a unanimity expert group, the greatest critical success factors of the Australian building industry and to evaluate the degree of agreement/disagreement among project managers (using Delphi techniques) regarding the ranking of the Relative Importance Index (RII).
5) To identify the cooperation among the ratings of consultant owners and contractor groups for (RII).

Therefore, project managers who are working in and handling construction works in different provinces in Queensland, Australia, participated by filling out a well-planned questionnaire survey. The critical success projects were rated using a relative importance index (RII). The data collected from the survey indicate the principle projects that have an impact on construction productivity in Australia.

1.4 STATEMENT OF THE STUDY

The construction industry is a significant activity within major economies. It dominants and is dominated by the nation’s gross domestic product (GDP).

The worldwide economic and monetary crisis of 2008 put an end to a season of maintained powerful growth in the building/construction area. At the same time, the need for mining and construction projects continues to stay powerful, while the rest of the construction sector is encountering an essentially shaky environment (Muhwezi, Acai & Otim 2014; Ridout & King 2008). The construction industry has significantly expanded its importance as a percentage of the Australian economy in the last ten years. The rise from 5.6% of the total industry amount added in 1996–97 to 7.3% in

2006–07. The construction industry in Australia constitutes almost 320,000 companies. In general, the construction industry in Australia hires over than one million people and 9.3% of the total workforce is working in construction as of August 2008, an increase from 7.3% ten years previously.

On the other hand, in 2010–2011, as consistent with business profits combined, the construction industry subsidizes 7.7 % of the Australian national income, totalling $102 billion and hiring 1.034 million of the tradespeople (Australian Bureau of Statistics 2012). This represents a rise from 7% of the national income, or $77 billion, in 2009–2010 and a share of the continued expansion from 2000–2001 (Australian Bureau of Statistics 2010).

Furthermore, during the last ten years the work rate in the building/construction business has eclipsed that of the overall economy because of a higher level of multifactor productivity; 1.4% regularly over this duration. The multifactor productivity quota rates combined unit of capital and labour input, and is usually assigned as a part of technological change.

On the other hand, Australian productivity has suffered deterioration in volume over the last few years. The deterioration has culminated in highly competitive circumstances for contracting firms, with more numbers striving for work than are found in other businesses. Furthermore, construction companies are exposed to productivity problems, leading to failure more often than is the case in other industries (Parham 2005).

This particular matter offers productive ground for research on work rate problems in the Australian construction industry. The liability for the delay and overdue nature of the study of low construction productivity lies with the project managers and contractors, but there are some other projects, which are causing hindrance and delays, such as delays in progressive payments. The investigation will examine the majority of the projects and their severe impacts on construction productivity in Australia.

Construction productivity has an inverse relationship with expenses and costs. Enhancing productivity is of significant interest to contracting firms, as reducing their expenses and costs will maximise their returns and make them more competitive. A contractor who can boast high productivity levels can offer a lower bid price to win a contract and still make sufficient profit, which will secure their share of the market. This shows that the research and analysis of building/construction productivity is a significant no..

Productivity improvement programs (PIP) are easy to achieve, especially in identifying and eliminating unnecessary work expenses and enhancing work effectiveness; a great number of the construction companies who applied PIP program have gained from them (The Engineering News Record 2004). Consequently, construction-contracting organizations should take advantage and make gains from this practical experience. After all, the management team in any construction company with their experience and responsibility for construction productivity are the essential target for the success and achievement of this program, and so it is necessary to examine and assess both the project managers' and contracting firms' views towards work rate/productivity, and their impression of these programs.

1.5 RESEARCH QUESTIONS

The experience of those who have investigated obstacles in construction productivity and the study of some projects in the Australian building industry that encountered productivity problems are confirmed in the outcomes of this research. Universal contracting firms' obstacles include: finishing and delivery of the project being delayed or behind schedule; low quality standard, using unidentified construction materials; budget overruns; unskilled tradespeople and artisans; project collapse or disengagement; faulty construction approaches; sustainability difficulties; and site protection from safety problems.

This study recognises related weaknesses for project owners. Owners' common problems in building businesses are overdue payments for finished work; proprietors' monetary problems; proprietors' obstruction and disorganisation; and delays in managerial decisions. Moreover, there are some obstacles with proprietors or administration parties imposing some bureaucratic rules over contracting firms and creating impractical demands or requests after sealing the contract. Part of these particular orders encompasses demanding specific contracting companies or specific materials, or reducing the work for some projects in order to save money. In addition, some stakeholders' agents are thrifty with contracting groups; this will reduce the money contractors can make on their projects.

On the engineering side complications include: miscalculations and inaccuracy in design reports; long delays in generating design reports; insufficient drawing munities; imprecise drawings; complications in the design specifications; and communication problems between the staff and lack of coordination between project terms. Moreover, engineers and project managers sometimes unsuccessfully implement mandatory pre-competence measures and fail to rely on valid data from the contracting firms/companies. Negotiations by contracting firms can be indiscriminately honoured without carrying out enough investigations to double-check that the formerly completed projects mentioned in the negotiations are legitimate and properly completed by the reputable contracting firms.

All these obstacles have an influence on the groups involved, likely creating great Losses for all the parties. All these threaten the safety of the construction projects, which surely will affect not only productivity, but also the whole economy. In view of all these issues, this study examines these obstacles to highlight the critical success factors in order to focus on the significance of the detracting critical success aspects that could prevent or eliminate construction productivity obstacles. This study recommends implementing these critical success factors and that using extra precaution is not enough to empower the project parties to avoid other critical aspects during construction projects. In addition, the research examines in depth the interrelationships among the critical success aspects, and the other critical aspects that will permit contract groups and stakeholders to decide which factors need immediate consideration.

The study investigates the following:

1. What are the actual sources of the factors hindering construction industry productivity in the Australian construction industry?

2. How are all these aspects associated with the aspects that detract from achievement in Australian construction industry?

1.6 RATIONALISATION OF THE STUDY

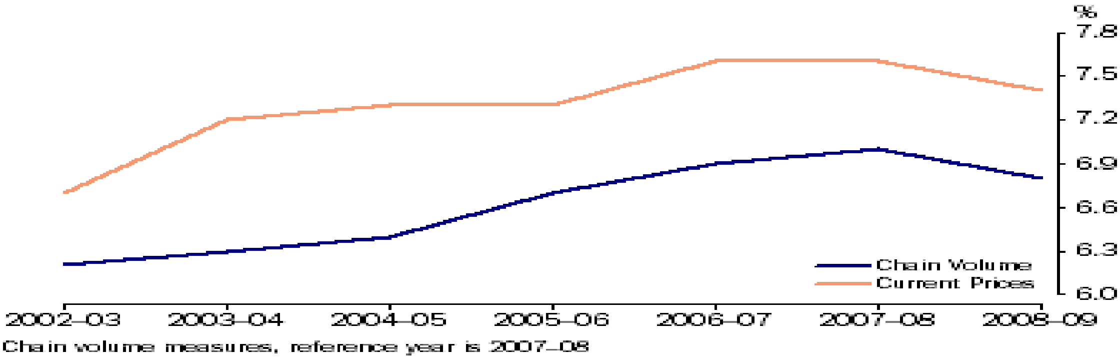
It is well known internationally that the building/construction industry is the backbone of any country's economy, and influences and is impacted by the country's gross domestic product (GDP) (Muhwezi, Acai & Otim 2014; Cox & Hampson 1998).

Since the 1991 economic downturn, Australia has gone through powerful work rate efficiency. The accumulated workers' work rate improved by 30 per cent between 1990 and 2006, compelled by powerful work rate improvement during the whole of the 1990s; this has been followed by a decline (Megha & Rajiv 2013; Parham 2005). For example, the contribution to gross domestic product is the entire market cost of merchandise and services produced in Australia over a certain time, after subtracting the expenses of the merchants and services involved during the production, but before subtracting the contribution for the consumption of fixed capital. This achievement is superior to the Organisation for Economic Co-operation and Development average. Thirteen work rate/output improvement were followed by improved working capital composition, and expanded workers' participation, so that, by 2007, the unemployment ratio had decreased to a 32-year low (Tressel 2008).

In addition, during this time, Australia also actively expanded its contribution to investment in the data and exchanging information technologies. Not all nations are encountering increase in the work rate. For instance, the work rate of the building/construction businesses in New Zealand is likely to be level (Tran & Tookey 2011). In the United States of America, it has been stated that the work rate of the construction businesses has steadily deteriorated (with a few moderate exceptions) over the last four decades (Holt & Gary 2014; Teicholz 2013). Given the consequences of building/construction work rate for the economy and these discrepancies between countries in its improvement over time to this point, it is important to realise and to master the issues in construction productivity for more development and enhancement.

In general, circumstances, the building/construction industry has been increasingly recognised as a part of GDP from 5.4% in 2001–02 to 6.2% in 2002–03 and from 6.8% in 2006–07 to 7.0% in 2007–08, but it was still around 6.8% in 2008–2009, its minimum level since 2006–2007. The building/construction industry was Australia's fourth best contributor to GDP through 2008–09, in present market conditions. It rated behind financial and insurance services (10.8%), manufacturing (9.4%), and mining (7.7%) (Figure 1.1) (Australian Bureau of Statistics 2008).

Figure 1.1: Industry gross value added, as percentage of total GDP



Chain volume measures, reference year is 2007-2008 -Source: Australian System of National Accounts (ASNA), 2008–2009

This achievement is almost the same as that of the United States of America for a like extent of time and more improved than that of the Organization for Economic Co-operation and Development (OECD).

The construction industry is complex in description because it consists of a considerable number of groups: clients, contractors, consultants, stakeholders, shareholders and others. Construction productivity in Australia experiences some complicated problems for many projects and issues.

This research identifies and evaluates the crucial issues hindering construction productivity in Australia (using the southeast Queensland area, which has a large number of construction projects, as an example). From the literature survey and questionnaire analysis conducted during this research, the facts concerning poor productivity and its slowdown are as follows: rework, incompetent supervisors, incomplete drawings, shortage of building components, work overload, very poor communication problem, poor site conditions, poor site layouts, overcrowding, inspection delays, absenteeism, workers turnover, accidents, tools and equipment breakdown due to poor maintenance, also shortage of tools and equipment; all are analysed in order to discover the main practical problems relating to construction productivity in Australia and then to define recommendations to improve and enhance construction productivity in Australia.

This study is a pioneer of its sort to examine the main critical projects of construction productivity in Australian. These investigations represent a concrete foundation for future research to take place. Internationally, the results of this study and its investigations could help as evidentiary data from which alternative comparative research could improve in different circumstances such as artistic, communal, bureaucratic, and environmental matters.

1.7 THE STUDY'S TECHNIQUE (RESEARCH METHODOLOGY)

The study/research technique used for this study/research is based on three stages:

1. Step one – literature survey to decide the study focal points.
2. Step two – a questionnaire survey as follows:
   - 2.1 Exercise one – specific questionnaire survey to all project managers (PMs) to identify productivity problems and hindering factors
   - 2.2 Exercise two – follow-up on the questionnaire in order to collect the highest number of participant responses

3. Step three – the Delphi process, a favoured subjective investigation, is applied to obtain assessment from a specific group of Australian professionals to sequence the preferred projects for achievable advancement to enhance project productivity in the Australian construction industry.

1.8 THE MAIN RESEARCH FINDINGS

The construction industry is a main provider to Gross Domestic Product in the Australian economy and decides the progress of the national economical position.
The study was built on a questionnaire survey. The survey was achieved on two rounds. The first survey round was a standard/general survey which reported on the

rating given by experienced project managers in a variety of the construction companies. The second round was a Delphi validation survey. In the Delphi approach, analysis can include both qualitative and quantitative information. Qualitative information in the Delphi technique deals with unrestricted questions to canvass opinions in the first round. The redundancy procedures are to classify and reach the goal stage of general agreement and also smooth out any variation of opinions between panel members (Hasson, Keeney & McKenna 2000).

The first round survey, which identified 23 primary factors and 25 secondary aspects with substantial effects on the construction productivity, has both confirmed that there are a few problems in the construction productivity in the Australian construction environment and investigated the main factors affecting the construction productivity in this environment. These factors were ranked according to their RII as ranked by experienced project managers in the construction industry. For example, rework was ranked number 1, incompetent supervisors number 2, incomplete drawings number 3, lack of materials number 4, work overload number 5, poor communication number 6, poor site conditions number 7, poor site layout number 8 and so on (Hughes & Thorpe 2014). These aspects were calculated and ranked with regard to RII in Table (4.10 b) and then discussed.

The Delphi validation survey was sent to a group of experts in the construction industry in order to confirm the findings of the first round survey. The collected data from the Delphi survey respondent project managers was analysed and ranked according to RII and tabulated in Table 5.4. A comparison between the RII rankings for the two surveys was tabulated and explained in Table 6.5. The validation of the responses between the four groups of project managers (academics, consulting engineers, public works, and contractors) were calculated and analysed in Table 6.2.

The Delphi validation survey included four open-ended qualitative questions, which identified some new factors not previously identified. It covered some issues related to government regulations, councils, and construction unions, which are explained in Section 6.10 – Thematic modelling of responses to the Delphi second stage qualitative survey.

Chapter seven concludes the study and offers some recommendations for further research.

1.9 THESIS STRUCTURE

This dissertation consists of seven chapters as follows:

Chapter 1 – Research introduction. This chapter discusses and explains the history of the investigations by presenting the research obstacles, the research principle, the research interests, and confirmations for the research, suggested technique, and dissertation organization.

Chapter 2 – Literature survey. This chapter gives a history of the construction industry across a wide spectrum. It surveys the construction industry in Australia and classifies aspects of the construction area. Constraints plus obstacles in the improvement of the construction industry in Australia and some other well-established countries are communicated. In addition, Chapter 2 describes the main roles of the construction industry in the economies of Australia and some well-established regions. Also, it gives the actual scope of former investigations to pinpoint the essential causes affecting the construction productivity in Australia; for example, the scope of the construction industry in Australia, and aspects influencing building/construction industry productivity such as lack of skilled labour, lack of materials, insufficient drawings, shortages of tools and equipment, revising of works, amendment to a construction contract, poor maintenance of tools and equipment causing breakdowns, and some other projects.

Chapter 3 – Methodology. This chapter describes the main methods used in this research in order to accomplish the purpose. The technique and the methodology are looking for identification of the roots of the critical/delay aspects and then arranging the aspects mandatory for enhancing project achievement. This chapter is concentrating on the questionnaire survey structure and the consent form.

Chapter 4 – Outcome and analysis. This chapter describes data compilation methods and investigation techniques and statistics (using the Statistical Package for the Social

Sciences or SPSS computer program) applied to describe elements of the obstacles to productivity in the construction and building industry in Australia. It presents the results of the questionnaire survey.

Chapter 5 – Delphi technique and methodology. This chapter is a literature review of the consensus-forming Delphi approach. This includes an examination of the history of the Delphi methods, the process of the Delphi methods and the shortcomings of the Delphi technique. Chapter 5 also discusses the analysis of data gathered from the professional expert group on the rating of the most required critical success issues.

Chapter 6 – Research discussion and evaluation of results. This chapter is dealing with the explanation for the Delphi data analysis, Delphi survey summary of data collection, relationship between critical success factors using relative importance index (RII) correlation, perceptions and influence of success factors (comparison of results for academics', contractors', public works' and engineers' responses), comprehensive discussion of achievement aspects (relative importance index) and groups' comprehensive recognised success factors importance. It includes a discussion of the qualitative Delphi Survey responses and construction productivity problems compared with other countries, then a summary.

Chapter 7 – Research conclusion and recommendations. Chapter 7 contains the conclusion and the outcome of the study, incorporating recommendations resulting from the findings and the validation survey (Delphi qualitative and quantitative second round survey).

1.10 CONCLUSION

A recent study shows that some of the construction tasks are either achieved with high-cost overruns or falling behind the timetable or both together which could be translated to a number of losses. These losses could affect some or all the parties involved in the task (Saleh 2008).

Many researchers investigated the causes of critical success factors and delay factors, how to identify them and how to find a solution or ways to avoid them in the first place (Chan & Kumaraswamy 1997; Baldwin 1971; Assaf et al. 1995; Al-Ghaffy 1995; Ongulana & Pramkuntong 1997; Odeyinka & Yusuf 1997; Kaming et al. 1997; Al-Momani 2000; Odeh & Bettaineh 2002. The critical success and delay factors could be concluded in time and cost overrun, disputes, litigation, arbitrations and desertion for the entire operations (Aibinu & Jagboro 2002; Murali & Uau 2006).

The study in this thesis is based on the previous studies and research by examining the critical success and delay factors they found. In addition, this study is examining the factors affecting the productivity in the construction industry in an integrated model (questionnaire survey as per chapter three the research methodology and questionnaire design).

If all the critical factors are identified, there is a great chance to improve the project performance and control the cost and delay overrun.

This chapter is dealing with an introduction to the study, the importance of the study, the objectives of the study, statement of the problem, research question, and justification of the research, research methodology and research outline.

More literature surveys about the critical success factors and the construction productivity in the construction industry in Australia will be continued in depth in Chapter Two titled literature survey to help and support the subject of this thesis.

CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

Construction is an essential industry in Australia. Its sales reached $327 billion, equal to 21 % of GDP (Department of Industry, Innovation and Science 20142014) and its share value added up to 7.6 % of GDP.

Data and information collected from the Australian Bureau of Statistics helps to investigate and evaluate productivity size and value in the construction industry and its divisions; building/construction accounted for 35 per cent, heavy/civil engineering building/construction accounted for 23 %, and construction services accounted for 43 % of the industry.

The term ‘productivity’ is used loosely in everyday language. The technical definition of productivity is “the measurable relation between the industry output and the workers and capital inputs”. In order to measure the output, the construction industry initiated the term ‘value added’, and for workers input the best measure is working hours. Australian construction workers’ productivity is extremely significant because it is one of the drivers of living standards.

Construction is an extremely constructive industry with a value added/worker above the average of all other industries. Some divisions of the construction industry, for example, heavy and civil engineering are extremely constructive, creating productivity 53 per cent higher than the Australian average (Richardson & David 2014).

As at November 2011, the building industry hired 1,039,900 workers (Australian Bureau of Statistics 2011), making the construction industry the fourth largest industry in Australia.

In August 2014, the Australian Bureau of Statistics (ABS) reported that the service division (65% of total GDP) governs Australia’s economy. So far, its economic achievement is established on the basis of large amounts of agricultural and mineral assets. The most significant and most progressive area of the economy is manufacturing, with mining contributing 13.5 per cent of GDP, manufacturing 11 per cent and construction 9.5 per cent; agriculture contributes the remaining 2 per cent of GDP.

This website – Australia GDP annual growth rate – provides actual values, historical data, forecasts, charts, statistics, economic calendars, and news (ABS Aug 2014).

Table 2.1 Australia GDP annual growth rate 1960–2014

Definite	Former	Topmost	minimum	Dates	Unit	Frequency
Three & a half	Two & 7/10	nine	(–)Three & 4/10	1960 To 2014	Percentage	Quarterly

Source: Australian Bureau of Statistics (ABS) August 2014

The achievement level of building/construction productivity is the stage to which project goals and anticipations are met (Megha & Rajiv 2013; Arslan & Kivrak 2008). The particular objectives and predictions can incorporate technological, monetary, academic or vocational, communal and professional factors. Investigators classified the achievement principles for everyone in the contract group: proprietors, engineers, and contracting firms. Some of the proprietors' achievements principles cover delivering the project on time, within the financial plan and profit on capital. In the engineers' case, achievement principles are customer fulfilment, quality structural production, and civil prominence. Lastly, contracting firms' benchmarks for weighing achievements incorporate finishing the project on time, creating profits, carrying out construction works within financial plans, site safety, and stakeholders' happiness.

The three essential groups in any construction project are the owners, engineers, and contracting firms. They all have common goals; such as considering that the capital to establish a construction project and the timetable to finish the project on time are the only criteria to weigh the ultimate achievement for a construction project. On the contrary, there are more exclusive criteria, such as the contractor trying to find a project that will boost the standard of experience for their staff. Safety issues are another major category for contracting firms. The proprietor is mainly looking for the proper skilled tradespeople to do the work professionally, and the project built to the highest standard for its intended use, with minimal defects for minimal maintenance obstacles and costs.

This research links some projects, for example, validity of construction productivity and achievement aspects in the construction industry. A few aspects are more significant and so needs management's attention in order to achieve high productivity. The four critical productivity success factors (CPSFs) are identified as follows:

1. Well-organised, united working group to manage, plan, erect and produce the work.
2. A series of contracts that allow and encourage different consultants to work as a group in harmony and with united aims and goals.
3. Strong backgrounds in administrations and authority, outlining, architecture, structure and operation of comparable facilities.
4. Appropriate, costly optimisation of the data from the proprietor, stakeholder, architecture, contracting firm and engineer in the outlining and design phase of the project (Mengesha 2004).

All the above factors indicate the necessary and need to create a cohesive, well-united, and cooperative team to increase the productivity in a construction project. The group of tradespeople and staff selected by the proprietor drives the whole of the project procedures and is known as the facility group. This group begins with limited projects and grows in size to include various members of management, architectural, development, construction, and operation groups to run the entire construction project.

In this chapter, the literature for construction productivity in Australia is reviewed in four parts as follows:

First, the significant influences of the construction industry on Australia's economy are reviewed. The construction industry in Australia is a significant contributor to its economy. It motivates and is motivated by the nation's GDP (Megha & Rajiv 2013; Cox & Hampson 1998). In Australia, for example, in 2010–2011, as evaluated by industry total value added, the building/construction industry provided 7.7 % to the Australian economy, totalling $102 billion and hiring 1.034 million persons

(Australian Bureau of Statistics 2012-2013). This shows that there was a rise from 7% of the economy, or $77 billion, in 2009–2010 as part of an unbroken rise from 2000 – 2001.

In consideration of the 1991 economic downturn, the construction industry in Australia has reached high productivity performance, the ultimate capacity achievement. Accumulated artisan productivity/capacity rose by a margin of thirty per cent within 16 years (1990–2006), supported by high productivity/capacity growth all throughout the majority of the 1990s. This was pushed by a recession in more recent years (Parham 2005). This performance is greater than the OECD average. Thirteen construction productivity gains were accompanied by a solid working asset arrangement and expanded labour cooperation. In 2007, the number of people out of work had dropped down to a 32-year low. Throughout that time, Australia also strongly increased investment in information and communication technologies (Megha & Rajiv 2013; Tressel 2008). Many countries did not manage to improve, create, or realise their dreams in achieving economic growth. For example, productivity of the building/construction industry in New Zealand is likely to be level (Tran & Tookey 2011). In addition, in the United States of America, the work rate of the building/construction industry has moderately decreased (with exceptions) over the past four decades (Teicholz 2013). Indicating the importance of construction and building industry in the economy and these discrepancies among countries as to its progress over the time, it is wise and essential to pay attention with great consideration to the issues in construction performance, so that research can lead to implementation of more progress and improvement in Australia.

Second, the critical success factors influencing construction productivity are reviewed. These factors influencing productivity have been investigated by many researchers (Megha & Rajiv 2013; Kaming et al. 1998; Olomolaiye, Jayewardene & Harris 1998; Rojas & Aramvareekul 2003a; Teicholz 2001). Some (Hanna et al. 2005; Kaming et al. 1997a; Lema 1995; Makulsawatudom, Emsley & Sinthawanarong 2004; Minchin Jr. et al. 2003; Olomolaiye, Jayewardene & Harris 1998; Teicholz 2001; Thomas & Yiakoumis 1987; Wachira 1999; Thomas & Zavrski 1999) proposed an aspects model (using certain aspects, for example, nature of work, substantial factors, construction models used and architectural obligation) and an assumption approach as theories for investigating construction labour productivity.

A United Nations economics statement (Parham 2005) stated that, from a traditional position, two main sets of factors influence construction labour productivity requisites: managerial consistency and execution consistency. Managerial continuity encompasses environmental items of work, specification requisites, and architectural details and so on. Execution consistency relates to the work surroundings and how effectively the work is planned and carried out. Administration factors include climate, construction components and tools/equipment possibility, overcrowding and disorganized work sites. The main focus of this study is on execution consistency. Subjective access is used so that expert project managers were asked to evaluate, from their outlook, a figure of aspects pinpointed from the study as having ramifications for construction productivity.

Third, ways to measure construction productivity are reviewed. The matter of productivity measurement has the highest propriety, with many problematic issues, and ambiguous matters in dealing with construction. Much research has been accomplished for creating smart techniques, in order to measure effectively site productivity, to create an extra means for enhancing and improving construction productivity in the current market. In this research, the goal is to suggest a new technique while commenting on current approaches and methods for weighing construction work rates and possible ways to develop their use.

Fourth, improving productivity in the construction industry in Australia is reviewed. Construction productivity is an area influenced by many different factors, such as labour, materials, equipment and construction methods. Of these elements, labour comes first because without labour’s achievements, other assets cannot be taken advantage of and transformed into productive use. In addition, labour costs in construction represent between 25% and 40% of the direct capital cost of a project; accordingly, any advancement in labour capacity would contribute a great deal to the enhancement of overall productivity.

In the present market, contracting firms are stressed and striving to create some means of competing for projects with at least a little profit margin, although some of the giant construction companies are doing very well. The cost of construction labour, building components and tools/equipment costs are mostly the same in any country worldwide. Increasing productivity is the only way to sustain and improve the bottom line.

2.2 PRODUCTIVITY DEFINITION

Whiteside, 2006 defined the work rate/productivity as, “As the moderate direct worker hours to build in a unit of material.” It can be expressed as follows:

$$\text{Productivity} \quad = \frac{\text{output obtained}}{\text{input expended}}$$

Productivity is identified as the ratio of output to the total or a portion of the resources, such as workers, assets, energy, and raw materials, used to produce that output (Megha & Rajiv 2013; Tran & Tookey 2011). Accomplishing good productivity requires effective planning for the use of labour, definite, and intact detailed drawings, and limiting delays to the minimum, and as a result of the climate, secure workplace, high standard of work, and a dispute-free work site until finishing the project.

Another definition of productivity from the OECD is the proportion of a quantity quota of productivity to a quantity quota of construction use (Woodward 2004). This is a related approach with correlation being viewed across time or between dissimilar production entities, perhaps treated in the form of essential investments, workers or other acceptable inputs and outputs.

The capacity quota can disclose productivity in relation to the total assets used (multi-project production or all projects production) or to an individual project, for example, units of workers or assets or energy. From a project perspective, production is accordingly the ratio of production to the total or some of the assets such as workers, assets, energy, and raw materials used to produce that production. Accomplishing good production requires an effective use of workers, good and well-integrated designs, and no delays except due to climate, site safety, high standards of works, and a construction site free from any troubles. A reasonable approach, therefore, to weighing project

work-rate/productivity is the proportion between the
amount of the work produced and the whole expenses of the inputs (Holt & Gary 2014; McCabe, O'Grady & Walker 2002).

2.3 SIGNIFICANT INFLUENCE OF THE CONSTRUCTION INDUSTRY ON THE AUSTRALIAN ECONOMY IN COMPARISON TO THE USA

The construction business is the most significant resource for the majority of economies. It powers, and is affected by, the nation's whole/gross domestic product GDP (Chancellor 2015; Cox & Hampson 1998).

In 2010–2011, the construction industry provided 7.7% to the Australian economy, totalling $102 billion, and hiring 1.034 million tradespeople and other workers. This shows that there was a rise from 7% of the economy, or $77 billion, in 2009–2010 as part of an unbroken rise from 2000–2001. In 2008–2009, the construction business was the fourth highest provider to Gross Domestic Product (GDP) in the Australian economy compared to 2006–2007, when construction business was the fifth greatest business in present return terms, and its performance decides the national wealth and income growth. The construction business accounted for 6.8% of GDP in 2008–09, in comparison with 7.0% in 2007–08.

The building/construction industry makes an important input to the economies of many nations globally (Banik 2001). Although the construction business was the fourth largest contributor to the Australian economy in 2008–2009, and in 2006–2007 the fifth greatest business in return terms at that time; it was rated behind the real estate market and business services (12.2%), fabrication and manufacturing (10.3%), finance and insurance (7.2%) and mining (7.1%). The construction business went through a downturn for a hard seven years of growth as a percentage of GDP, partly due to the establishment of the Goods and Services Tax (GST) in 2000–2001.

The construction industry works in two areas, first the independent area and second the government area. The work is engaged in three different areas of activity: urban development, non-urban development, and engineering production. Currently, bureaucracy procedures that encourage residential and infrastructure projects have been in force. The affordability of resources, for example labour and construction workforce, and building components, is also creating changes in the construction industry (Australian Bureau of Statistics 2008-2009).

Recently, the media has been concentrating on the shortage of urban development and the insufficient housing in Australia's largest cities due to unavailability and un-affordability. In 2009, the Australian media paid close attention to Australia's economic response to the worldwide financial crisis, after which time the government increased the budget for infrastructure projects. More concentration has been given to the issues of government involvement in inspiring economic growth and keeping up the need for workers, specifically for the construction works for dwellings and educational buildings (Perham 2005).

In the USA, the construction industry is also a main source for generating employment and provides a significant share of GDP. In 2007, around eleven million persons, representing almost eight per cent of the entire US workforce, were employed in the construction industry. The financial worth of the constructions and infrastructure that they constructed was valued at $1.16 trillion dollars (US Census Bureau, 2008a). On the other hand, the building/construction industry considered for $611 billion, or 4.4 percent of the GDP, an extra than other industries, inclusive information technology, crafts and amusement, services, agriculture, and mining (US Bureau of Economic Analysis 2009). Construction's part of the GDP would increase to 10 per cent if the equipment, furnishings, and energy needed to complete constructions were included (National Committee on Science, Technology, Engineering, and Math Education, USA 2008).

Construction productivity is affected by many factors such as effective and accurate specifications, sophisticated scheduling for finishing the project or the infrastructure fast or on time and effective cost analysis to finish the project and the infrastructure with low cost and within the project or the infrastructure budget. All these factors directly influence the prices for houses and consumer goods and the size of the national income. Construction productivity has an impact on the consequences of national activities to modernise current infrastructure systems; to construct new infrastructure from existing assets; to improve high-quality "green" buildings; and to stay active in the world market. The National Committee on Science, Technology, Engineering, and Math Education, USA, NSTC 2008) stated that changes in building design, construction, renovation, building components and materials recycling are essential to the success of national efforts to minimise environmental effect and minimise energy consumptions and greenhouse gas diffusions.

2.4 CONSTRUCTION INDUSTRY INTERPRETATION

The construction industry incorporates those businesses principally involved in the construction of urban development, commercial and industrial buildings, including refurbishment modifications and extensions, engineering architecture and any connected trade services identified under the Australian and New Zealand Standard Industrial Classification (Australian and New Zealand Standard Industrial Classification, ANZSIC 2006).

2.5 CONTRIBUTION TO GROSS DOMESTIC PRODUCT (GDP)

GDP is the total market worth of goods and services produced in Australia during a certain time, after writing off the expenses of materials and labour used in the manufacturing or production, and before writing off the contribution for the expenditure of settled capital. The construction business has progressively expanded as a dividend of GDP from 5.4% in 2001–2002 to 6.2% in 2002–2003 and from 6.8% in 2006–2007 to 7.0% in 2007–2008, but it reduced to 6.8% in 2008–2009, its minimum level since 2006–2007. The construction industry was Australia's fourth largest donor to GDP during 2008–2009, rating behind monetary and insurance services (10.8%), manufacturing (9.4%) and mining (7.7%) (Figure 2.1) (Australian System of National Accounts 2008–2009).

2.6 CONSTRUCTION WORK DONE AND ITS EFFECT ON THE AUSTRALIAN ECONOMY

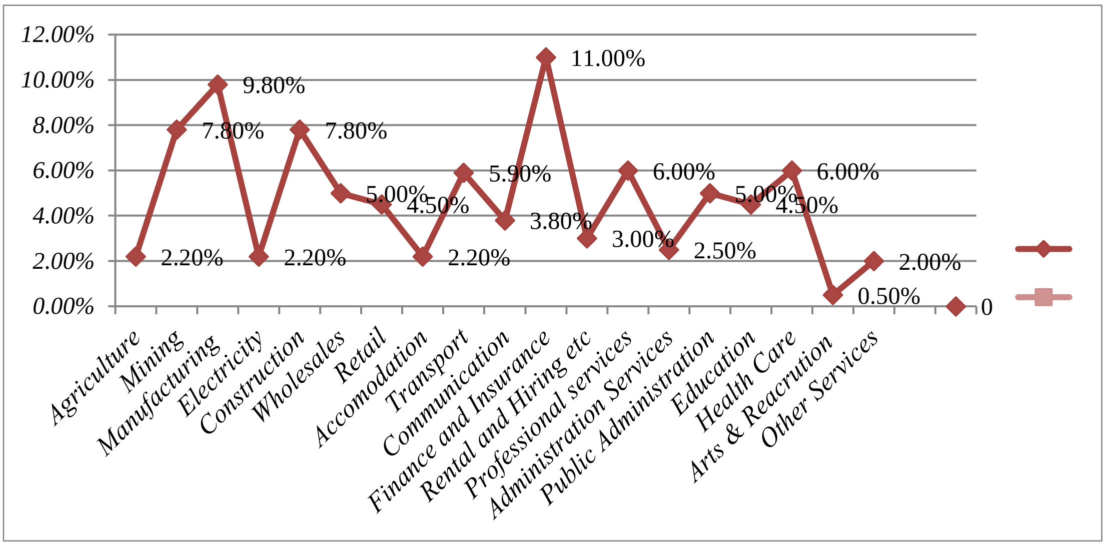
The financial worth of construction production performed during 2008–2009 was $151.3 billion, an eleven per cent rise from the past fiscal year. The previous five years to 2008–2009 demonstrated an increase in the capital worth of the construction production performed on building and architectural construction from 10.1% and 84.2% respectively. This inconsistency in capital rates was due to the separation of the building business and architecture work in Australia. Building construction was 62.5% of total construction in 2004–2005, and 50.2% in 2008–09 (Table 2.2). These figures show the importance of the construction production on Australian growth.

Table 2.2 Industry performance, construction –current prices

Industry	Ratio of GDP	Industry	Ratio of GDP
Agriculture	2.2 %	Finance and Insurance	11 %
Mining	7.8 %	Rental and Hiring etc.	3.0 %
Manufacturing	9.8 %	Professional services	6.0 %
Electricity	2.2 %	Administration Services	2.5 %
Construction	7.8 %	Public Administration	5.0 %
Wholesales	5.0 %	Education	4.5 %
Retail	4.5 %	Health Care	6.0 %
Accommodations	2.2 %	Arts & Recreation	0.5%
Transport	5.9 %	Other Services	2.0 %
Communication	3.8 %	Blank	Blank

Source: Australian System of National Accounts 2008–2009

Figure 2.1 Industry total value added, ratio of GDP by industry



2.7 INDUSTRY PERFORMANCE

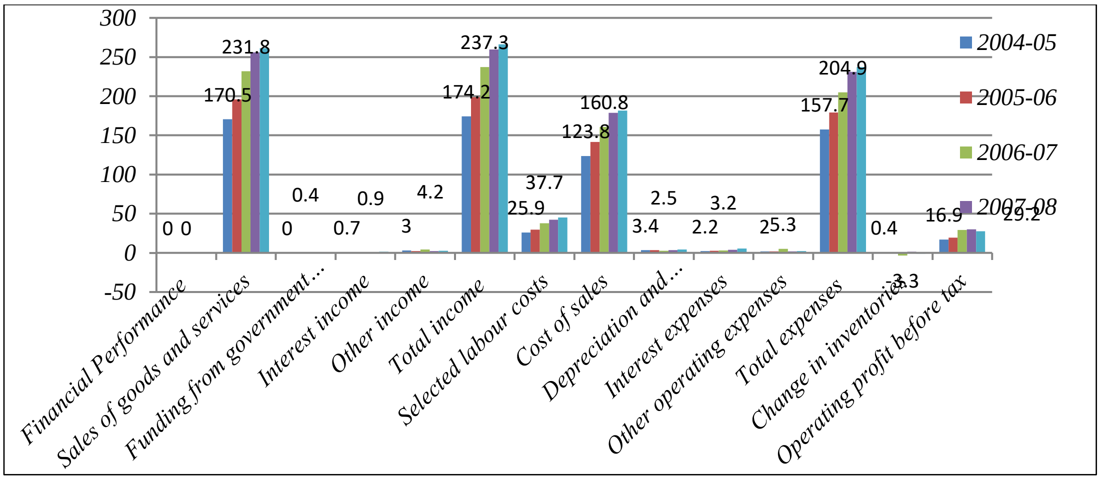
The assessment of construction production carried out in 2006–2007 estimated it at $112,817.1 million, 5.7% more than the previous fiscal year 2005–2006 (Australian Bureau of Statistics 2008), but in 2006–2007, the greatest part of construction work was engineering construction at $47,538.5 million, equal to 42.1% of all construction production. In 2008–2009, the gross return profit before deducting tax for construction work was $27.6 billion, a decline of 8.0% on the previous fiscal year 2007–2008. Total income rose from $259.7 billion in 2007–2008 to $266.1 billion in 2008–2009, an extra 2.5%. Total expenses rose from $231.0 billion in 2007–2008 to $237.3 billion in 2008–09, an increase of 2.7% (Table 2.3 and Figure 2.2) (Australian Industry 2008–2009).

Table 2.3: Industry performance, construction – current prices

	2004–2005	2005–2006	2006–2007	2007–2008	2008–2009
Financial performance	$b	$b	$b	$b	$b
Sales of goods and services	170.5	196.1	231.8	256	261.4
Funding from government for operational costs	0	0.1	0.4	0.3	0.7
Interest income	0.7	0.6	0.9	1.1	1.4
Other income	3	2.1	4.2	2.4	2.6
Total income	174.2	198.8	237.3	259.7	266.1
Selected labour costs	25.9	29.6	37.7	42.4	45.1
Cost of sales	123.8	141.5	160.8	178.8	181.7
Depreciation and amortisation	3.4	3.6	2.5	3.4	4.1
Interest expense	2.2	2.7	3.2	3.7	5.6
Other operating expenses	2	1.8	5.3	1.8	2.3
Total expenses	157.7	179	204.9	231	237.3
Change in inventories	0.4	0	3.3	1.3	–1.2
Operating profit before tax	16.9	19.5	29.2	30	27.6

Source: Australian Industry 2008–09

Figure 2.2: Industry performance, construction – current prices



Source: Australian Industry 2008–2009

2.8 SIGNIFICANT INFLUENCE OF THE CONSTRUCTION INDUSTRY ON BUSINESS INVESTMENT

In 2008–2009, independent new capital disbursements in the construction business were $4.1 billion, an extra percentage of 0.4% on the 2007–2008 fiscal year. During that period, disbursements to all industries rose by 16.9%. Growth of disbursements for the construction business in 2008–2009 was at its minimum proportion since 2002–2003 and less than the improvement proportion of the total industries for the first time since 2005–2006 (Average Weekly Earnings Australia, AWEA 2006).

The construction industry was the tenth largest donor to independent new capital in 2008–2009 at 3.6% of the total, while the biggest disbursements by an individual industry were in mining, donating 33.6% (Table 2.4). This numeral indicates the maximum of the construction industry on Australian business investment.

Table 2.4: Private new capital expenditure (current prices), construction industry

	2005–06	2006–07	2007–08	2008–09
	$b	$b	$b	$b
Construction	3.1	3.4	4.1	4.1
Total All Industries	80.6	87.5	96.8	113.1

Source: Private new capital expenditure and expected expenditure, Australia (ABS 2009)

2.9 SIGNIFICANT INFLUENCE OF THE CONSTRUCTION INDUSTRY ON THE LABOUR MARKET

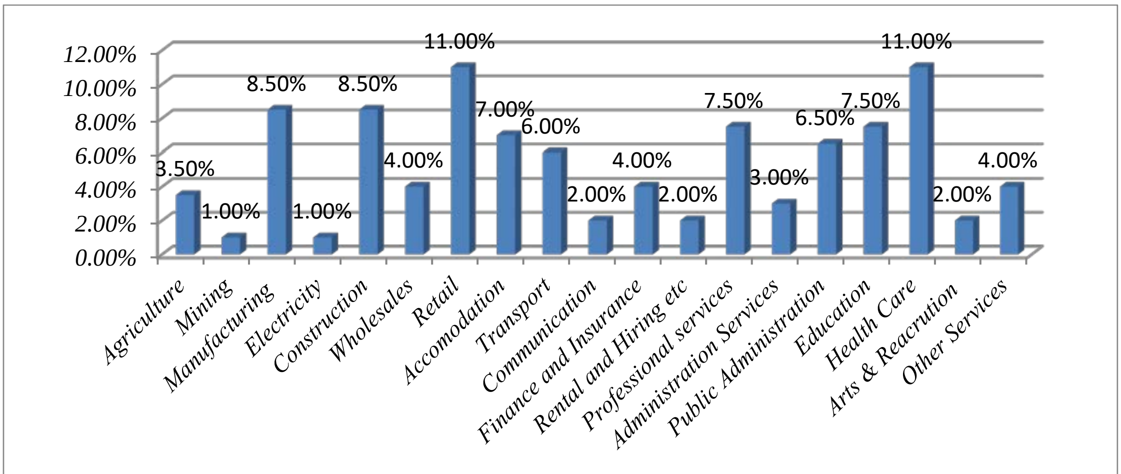
The construction industry is well known as the fourth largest recruiting industry in Australia. As of the May 2010 quarter, there was 984,100 staff working in the building/construction industry, representing 9.1% of the total personnel. It was the fourth largest employing industry behind retail trade (11.2%), health care and social assistance (11.0%) and manufacturing (9.2%) (Figure 2.3) (ABS, Labour Force Australia, LFA 2010).

Table 2.5: Employment by industry, percentage of total employment

Industry	Employment %	Industry	Employment %
Agriculture	3.50%	Finance and Insurance	4.00%
Mining	1.00%	Rental and Hiring etc.	2.00%
Manufacturing	8.50%	Professional services	7.50%
Electricity	1.00%	Administration Services	3.00%
Construction	8.50%	Public Administration	6.50%
Wholesales	4.00%	Education	7.50%
Retail	11.00%	Health Care	11.00%
Accommodations	7.00%	Arts & Recreation	2.00%
Transport	6.00%	Other Services	4.00%
Communication	2.00%	Blank	00%

Source: Labour Force Australia, Detailed, Quarterly, May 2010

Figure 2.3: Employment by industry, percentage of total employment



During the period of 36 months from May 2006 to May 2009, the construction industry increased the number of hired people from 892,100 to 984,100, a rise of 10.3%; in the same period, the proportion of hired staff in all other industries rose by 5.6%. Of the 984,100 people employed in the construction business, 65.4% were working in construction services, 23.5% in the sector of building construction, 7.1% in heavy and civil engineering construction, and 3.9% in other general construction works (Table 2.6) (Australian Bureau of Statistics 2010; Labour Force Australia (LFA) May 2010).

Table 2.6: Persons employed, construction industry – May 2009

	May 2006 '000	May 2007 '000	May 2008 '000	May 2009 '000
BUILDING CONSTRUCTION				
Residential building	71.0	70.0	90.0	73.0
Non-residential building	41.0	42.0	43.0	48.0
Building construction, nfd	100.0	104.0	115.0	110.0
Heavy and civil engineering construction	48.0	74.0	60.0	70.0
CONSTRUCTION SERVICES				
Land development and site preparation	53.0	51.0	55.0	48.0
Building structure services	87.0	83.0	95.0	91.0
Building installation services	182.0	211.0	212.0	226.0
Building completion services	192.0	181.0	201.0	189.0
Other construction services	96.0	89.0	88.0	85.0
Construction services, nfd	4.0	7.0	3.0	5.0
Construction, nfd (b)	18.0	25.0	15.0	38.0
Total construction	892.0	937.0	976.0	984.0
Total all industries	10 213.0	10 523.0	10 755.0	10 782.6

All data presented are for May quarter (b) nfd – not further defined.

Source: Labour Force Australia, Detailed, Quarterly, May 2010

2.10 SIGNIFICANT INFLUENCE OF THE CONSTRUCTION INDUSTRY ON AVERAGE WEEKLY EARNINGS

Average weekly earnings (AWE) for staff and tradespeople who are involved in the construction business are above the normal compared with all other industries. This includes full-time mature workers and all other workers. Adding to this, in May 2009, the AWE for full-time mature workers, and all people in the construction business were 7.9% and 26.8% above the AWE for all other industries, respectively. For all workers in the construction business, the AWE rose to 25.8% between the years 2006 and 2009, in comparison to a growth of only 12.1% in all other industries (Table 2.7 and Figure 2.4) (Australian Bureau of Statistics 2010; LFA 2010).

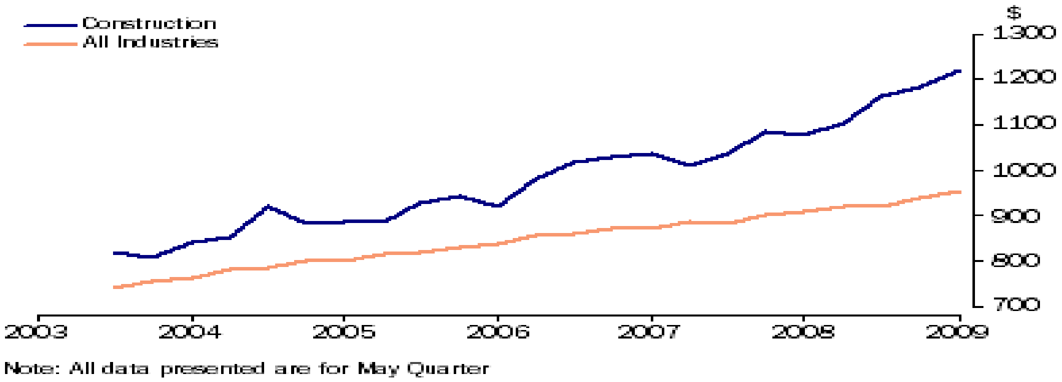
Table 2.7: Average weekly earnings, construction and all industries

	2006	2007	2008	2009
CONSTRUCTION INDUSTRY	$	$	$	$
Full time adult, total earnings	1 067.1	1 167.6	1 225.0	1 332.2
All employees	926.4	1 018.2	1 036.7	1 165.0
ALL INDUSTRIES				
Full time adult, total earnings	1 073.6	1 124.1	1 171.5	1 234.9
All employees	819.7	858.5	885.0	918.6

(a) All data presented are for May quarter 2010

Source: Average Weekly Earnings, Australia, May 2010

Figure 2.4: Average weekly earnings, all employees



Source: Average Weekly Earnings, Australia, May 2010

2.11 SIGNIFICANT INFLUENCE OF THE CONSTRUCTION INDUSTRY ON EMPLOYMENT STATUS

Peoples who were hired in the construction business in May 2009, 72.5% (713,000) were employees, compared to 88.6% for all industries. People who were working on an ‘own account’ base represented the second largest group of employees in the construction business, at 22.1% (218,000). This compares to only 8.6% for all industries (Tables 2.8; 2.9 and Figure 2.5) (Australian Bureau of Statistics, Labour Force Australia 2010).

Industry	Labour force percentage	Industry	Labour force percentage
Agriculture	38	Finance and Insurance	4
Mining	1	Rental and Hiring etc.	8
Manufacturing	5	Professional services	12
Electricity	1	Administration Services	16
Construction	22	Public Administration	2
Wholesales	5	Education	5
Retail	5	Health Care	4
Accommodations	2	Arts & Recreation	12
Transport	12	Other Services	12
Communication	5	xxxxxxxxxxx	xx

Source: Source: Labour Force Australia, Detailed, Quarterly, May 2010

Figure 2. 5: Labour force, all industries, Australia

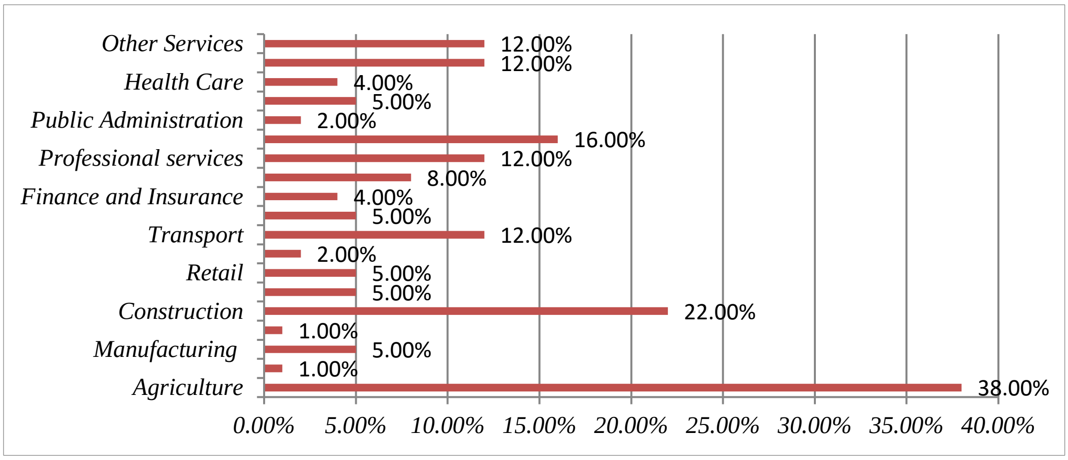


Table 2.8: Persons employed, by employment status – May 2009

Type of employment	Employee	Employer	Own account worker	Contributing family worker	All employees
Construction ('000)	713.0	49.0	218.0	4.0	984.0
% of total employment	72.5	5.0	22.1	0.4	100.0
All Industries ('000)	9 552.1	264.7	932.0	32.9	10 781.7
% of total employment	88.6	2.5	8.6	0.3	100.0

Source: Labour Force Australia, Detailed, Quarterly, May 2010

Table 2.9: Labour force, all industries, Australia

Therefore, the construction business in Australia is considered the second most likely industry to have workers working on an ‘own account’ basis. As of May 2009, 38.5% of workers in the agriculture, forestry, and fishing industries were ‘own account’ workers (ABS, Labour Force Australia 2010).

2.12 SIGNIFICANT INFLUENCE OF INDUSTRIAL DISPUTES ON PRODUCTIVITY

In the construction industry, the number of industrial disputes cases has increased by 73.3% over the past two years (2013/2014 – 2014/2015); the figure for 2008–2009 remains 81.6% lower than during 2004–2005. Industrial disputes cases in all industries have fallen 66.3% during the same period. In 2008–2009, the construction industry provided about 27.1% of all industrial disputes cases, despite having only 7.7% of all the staff engaged in such disputes. During 2008–2009, 12,900 staff in the construction business was engaged in one way or another in an industrial dispute case, twice the number for the preceding year. During the same period, the number of productive days lost in the building industry because of industrial dispute increased to 175.3%, distinguished from a 23.5% fall across all industries. The number of staff from the building/construction industry involved in industrial disputes has fallen to 84.3% since 2004–05, although subsequent loss of working days for staff has fallen to 80%.

In 2008–2009, the proportion of activity days lost per employee involved in industrial disputes in construction increased from 1.3 to 1.7 days, which represents the highest level since 2002–2003, although the proportion for all industries declined from 1.3 to 0.8 days over the same period (Table 2.10). Employees in the construction business involved in an industrial legal feud during 2008–2009 missed almost one more day of work in comparison with employees engaged in industrial disputes among all industries (Figure 2.6) (Australian Bureau of Statistics, Industrial Disputes Australia 2008–2009). These figures show the significant effect of disputes on construction productivity, such as the loss of working days, delays in project delivery, putting the project on hold until a dispute is solved and wasting money from the project’s budget, which affects project progress and delays.

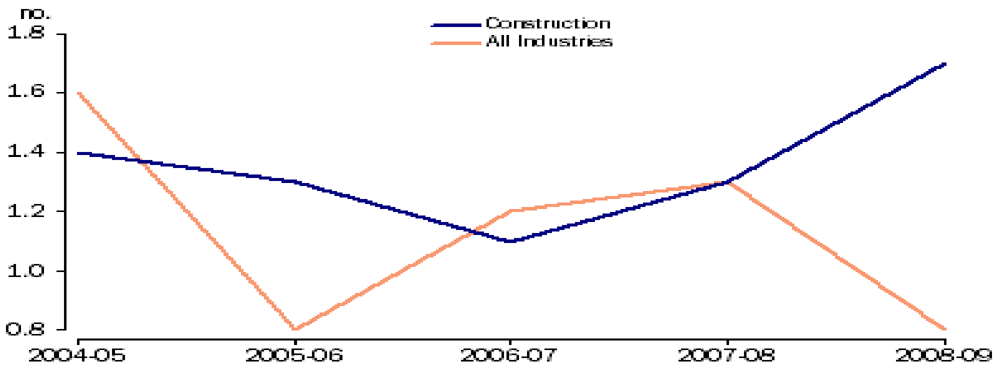
Table 2.10 Industrial disputes (construction industry, Australia)

	2004–	2005–	2006–	2007–	2008

	05	06	07	08	09
Construction industry					
Number of disputes (no.)	283	146	30	36	52
Employees involved ('000)	82.2	41.6	8.1	6.4	12.9
Working days lost ('000)	111.9	52.4	9.3	8.1	22.3
Working days lost per Employees involved	1.4	1.3	1.1	1.3	1.7
All industries					
Number of disputes (no.)	570	354	144	166	192
Employees involved ('000)	156.2	227.1	73.4	131.3	167.0
Working days lost ('000)	243.2	188.6	88.7	164.9	126.2
Working days lost per Employees involved	1.6	0.8	1.2	1.3	0.80

Source: Industrial Disputes Australia (ABS 2008–2009)

Figure 2.6: Industrial disputes, working days lost per employee



Source: Industrial Disputes Australia (ABS 2008–2009)

2.13 SIGNIFICANT INFLUENCE OF THE CONSTRUCTION INDUSTRY ON THE AMERICAN ECONOMY

The construction industry is a creator of progress for the US economy. The contribution to an industrial plant and facilities, in the form of construction work, supplies the basis for the products' production and the delivery of services. Contributions to infrastructure advance the steady movement of goods and services and the flow of workers. The contribution to residential buildings allows existing residents to extend and enhance their own homes. The conclusion is that construction work has an impact on many factors in the US economy and the construction industry is very important to the continuation and improvement of the US economy. In 2008, the construction industry's contribution to GDP was $582 billion or 4.1 % of GDP (US Bureau of Economic Analysis 2009). In 2008, the value of construction put in place was $1072 billion (US Census Bureau 2009).

As the construction industry has a significant impact on the US economy, it also has a vital influence on US employment as well. In 2008, 11.0 million workers were hired in the construction industry (US Bureau of Labour Statistics 2009). This means that 7.6 % of the total US workforce is hired by the construction business. The structure of the construction workforce is distinct from most US workforces because of the huge number of freelance employees (sole owners and partnerships). In the construction business/industry, there are 1.8 million sole owners' employees. The great proportion of freelance employees both decreases the volume of the normal company and extends the distinction throughout the construction industry, as 79% of construction companies with staff have fewer than 10 staff (US Census Bureau 2002 a and 2002 b). These two factors make it difficult to adopt new technologies and practices. Construction industry recruitment is influenced by two factors: the climate and the market round. Accordingly, time-to-time alterations in recruitment can be significant; its outcome is represented in dismissal from jobs and control or tightening up of hiring. The periodic outlook of construction industry recruitment results in the lack of high-calibre workers and staff. The lack of workers, staff and experienced tradespeople has a negative impact on productivity in the construction businesses/industry. In conclusion, declining construction productivity is exacerbated by a flow of inexperienced tradespeople from overseas; most of them started their first jobs in the construction industry.

Comparing the current situation in the construction industry in the USA with its situation in the year 2000, for example, the construction industry hired some 6.7 million staff, with a payment of $650 billion dollars, representing almost 10% of the 1999 GDP (Banik 2001). The attitude, eccentricity, and output of the building industry have, however, also gained it a less than positive character (Love 2002 b).

In addition, different developments have been advised and many have endorsed the need for experienced managers to oversee projects; on the other hand, the productive achievement of project managers is the most critical aspect influencing successful project conclusion (Bandow & Summer 2001; Hartman 2000).

2.14 CONSTRUCTION PROJECT PARTIES: AUSTRALIAN CONSTRUCTION INDUSTRY

The following information is a description of construction project teams' performance. The essential members of construction project teams are:

2.14.1 Designer (architect/engineer)

An essential team member in construction projects is the architect or engineer, who carries out the project's owner instructions and develops the actual master plan of a project. In some projects, the architect/engineer also supervises the works at the construction stage.

2.14.2 Authority administrative agents

These agencies include, among others, councils, electrical services, public works departments, building, water, sewerage, structure, fire brigade, economic planning units, health, town and country planning, land departments and survey departments.

2.14.3 Owner (proprietor)

Proprietors play a very important part in the construction project cycle by explaining project requisites, operations, and aids. In addition, the proprietor provides monetary backing of a construction project.

2.14.4 Contractor/constructor/builder

Private construction companies normally enter into an agreement with the proprietors or owners in order to carry out a project or a construction work in accordance with particular requirements. The contractors, constructors, or builders are generally individual contractors who engage in constructing the construction works within specific considerations and ethical standards set by the project administrators. (The thesis author)

2.15 CONSTRUCTION PROJECT PARTIES: ROLES

2.15.1 Architect/engineer (A/E):

- is accountable for project design and drawings
- consolidates the concluding project
- decides which building components should be used and how they will be assembled together
- creates and improves the project’s designs, drawings, and blueprint.

2.15.2 Contractor:

- establishes the facility depending on the architecture and engineering plans and on technical specifications
- handles all the diverse assets during the project progress according to plan.

2.15.3 Owner:

- makes the final decision to go ahead with the project or cancels the project in the first place
- supplies the project with the necessary monetary requirements to start the project/work
- decides and plans the outlook of the project
- is the essential pillar in the entire project or project procedures.

  (The thesis author)

2.16 CONSTRUCTION PROJECT DEVELOPMENT IN THE AUSTRALIAN CONSTRUCTION INDUSTRY

Generally, construction works/projects develop in a definite sequential fashion and the normal steps are as follows:

- Depending on the final blueprint and drawings, the project is announced and the requirements for action, containing the entire project's expenditures for the construction work, are sought.
- The need for a facility is designated by the proprietor.
- Primary practicability and expenses prediction are refined.
- After receiving a request, the contracting firm is selected too and the order is given to start the activities.
- The design committee meets to confirm the approval to proceed with the project's essential design or replace it.
- Start of the procedures to erect the facility.
- The principal plans and purview of the activities are improved so that the cost can be decided.
- The final resolution is reached to go ahead with the latest revision of the design document.
- Finally, the construction work is completed and the project is handed over to the proprietor or the owner for use.

  (Enshassi et al. 2014; Hughes & Murdoch 2001)

2.17 CONSTRUCTION PRODUCTIVITY OBSTACLES

2.17.1 Contractors

The following factors are arranged in order of importance: climate, workforce provider, subcontractors, revising drafts and drawings, concrete establishment setting, insufficient building components, fabricated components, fragmented go-ahead, bureaucratic arguments, machinery breakdowns, agreements, construction misunderstandings, work examinations, resources and approvals.

2.17.2 Architects

The following factors are arranged in order of importance: subcontractors, labour, weather, manufactured items, finances, materials shortages, shop drawings, permits, foundation conditions, design changes, construction mistakes, sample approvals, building codes, contracts, machinery breakdowns.

2.17.3 Engineers

The following factors are arranged in order of importance: weather, subcontractors, labour, manufactured items, finances, foundation conditions, permits, materials shortages, revised drafts, plans and drawings, essential drawings, jurisdictional disputes, tools and machinery breakdowns, construction errors, inspections, agreements, sample approvals.

2.18 DEFINITION OF THE CONSTRUCTION INDUSTRY

The main goal of the building and construction industry is building residential dwellings such as houses, apartments, factories, offices, and schools, and infrastructure such as roads and bridges; these are just a sample of the works created by the construction industry. In addition, the industry's works involve the construction of new structures, including work site development, and also adding to and carrying out alterations to existing ones. The industry is also involved in maintenance works, fixing of damaged assets, and enhancing of these structures.

The construction business consists of three main divisions. The first division is responsible for the construction and building sector. Normally known as general builders or contractors, they usually build private and urban dwellings, industrial, commercial and other dwellings. The second division relates substantially to community architecture, and the main contracting firms carry out many types of works such as building sewers, roads, highways, bridges, tunnels, and many other elements of the country's infrastructure. Consultant firms carry out special kinds of projects and critical construction works associated with all kinds of construction, for example, carpentry, painting, plumbing and electrical work (US Bureau of Labour Statistics 2009).

In most cases, construction work is dominated and carried out by general contractors or general builders who have expertise in one or two kinds of construction work, for example, domestic dwellings, industrial buildings such as factories, companies, public buildings (for example, universities, schools and government buildings) or commercial buildings such as business buildings. Customarily, general builders or contractors have complete accountability for the entire project works and activities other than what is removed from the written work agreement. Despite the fact that general builders or general contractors carry out some of the contract work on their own, they hire subcontractors to carry out the remaining projects of the contracts works (US Bureau of Labour Statistics 2009).

Consultant and artisan contractors or builders normally perform one project of one profession, for example, painting, carpentry, or electrical work, or of two or more closely related professions, for example, plumbing and heating. Consultant and artisan contractors are not accountable for some works of the structure. Usually they get their work arrangements from general contractors, general builders, architects, or property owners and repair work is normally done on face-to-face order from owners, occupants, architects, or rental agents.

In the present, the current progress in the USA means the building/construction industry has been greatly influenced by the critical credit situation and inflation that started in December 2007. Dwelling prices have declined and foreclosures of houses risen high, specifically in overpopulated areas of the country. New house construction, while still ongoing, has declined sharply (US Bureau of Labour Statistics 2009). Indeed, the ailing economy will dominate some projects of construction works. Dealers and bankers will not build new stores and state and local authorities are minimising spending and tightening up budgets. Nevertheless, because energy prices have risen, many companies have started to change priorities and change their plans for the future by building or modernising buildings to be energy efficient. Green construction is growing rapidly because of its popularity and involves making construction as environmentally sustainable and energy effective as possible by supplying re-useable and earth-friendly products (US Bureau of Labour Statistics 2009).

2.19 DEFINITION OF PRODUCTIVITY

In the field of construction and building, productivity is measured by the direct labour working hours required for a building component. Perfect productivity is (1.0) in ideal conditions and is achieved in a forty-hour work per week, with all the tradespeople and staff getting their legal break times as planned. The overall design documents and drawings are ready and in perfect condition, there are no interruptions, very safe working conditions, all the works and activities on site are carried out perfectly, the climate in an ideal working condition is 21° C and the workplace is free of any dispute or legal action. In addition, productivity has been defined by Megha and Rajiv (2013); Tran and Tookey (2011) and Whiteside (2006) as the moderate direct worker hours to build in a unit of material. It can be expressed as follows:

$$\textbf{Productivity} \quad = \frac{\textbf{output obtained}}{\textbf{input expended}}$$

2.20 PRODUCTIVITY PROBLEMS IN THE CONSTRUCTION INDUSTRY IN AUSTRALIA AND THE USA

As in well-established nations such as Kuwait, Malaysia, Nigeria, and Saudi Arabia (Kaming et al. 1998), the Australian building/construction industry is experiencing, facing and struggling from setbacks and overwhelming expenditure due to all the factors that are signals of productivity complications. Australia faces similar problems to those found in other countries where poor productivity in construction has been investigated intensively. Enhancing construction capacity and output can be realised by overcoming construction obstacles and high expenditure. The construction industry in Australia has lately faced many gloomy considerations in the media. The following is some discussion of a number of these issues.

Increasing project/projects expenditure/costs:

One of the main problems the Australian construction industry is confronting recently and that continues to increase is project costs. The reason for this is the increase in the cost of construction materials, and the price of oil, the high value of the Australian dollar in 2015 and the banks' interest rates. All these aspects are influencing the productivity of the construction industry in Australia.

Control of construction quality:

Control of construction quality is a significant factor confronting the Australian construction industry. There is no code or requirement that exists to control the quality of services delivered. The construction industry has not itself created the standards of quality that should be handed to clients. Without establishing this,

quality control and standards in the construction industry could gradually collapse.

In this research, Australian construction productivity obstacles are investigated through a questionnaire survey of project managers. The following chapters of this dissertation deal with the methodology and analysis of the significance of the obstacles thus recognised. Its aims and goals are to identify Australian construction productivity problems.

Factors influencing construction productivity were also examined in nuclear power plants projects in the USA and many similar procedures were used to examine artisan capacity problems in Nigeria (Enshassi et al. 2014; Olomolaiye & Ogunlana 2006; Larbi & Olomolaiye 2003). From the existing literature on the construction industries of advanced countries such as Malaysia, Kuwait, Nigeria, and Saudi Arabia (Kaming et al. 1998), it is easy to recognise the main projects affecting construction capacity and outcome. In all, 38 out of 86 or more of the construction outcome obstacles (items) there identified are being examined through various construction projects in Australia.

- Shortfall in construction materials – this problem is caused because difficulties encountered with inconvenience in obtaining materials and the extra time needed to get them.
- Shortage of available funds faced by contracting firms due to not being paid on time for previous contracts.
- Absence of needed apparatus because of ineffective maintenance schedules, leading to multiple breakdowns.
- Machinery disruption due to ineffective maintenance programs for heavy equipment such as concrete pumps, cranes, batching plants and hoists.
- Rework – this points to both the cost of the time and the materials wasted to refurbish or rebuild defective work which is not acceptable to the construction

engineer because it is does not meet the standard's specifications or the building quality.

- Unstable team members – many of the trades swap between construction sites on instructions from their employer or sometimes they quit their jobs of their own accord for one reason or another.
- Artisan conflict – this is the loss of time and setbacks due to conflict between tradespeople and staff, and can be eliminated to improve the work planning.
- Artisans deserting the workplace – some tradespeople take time off work for one reason or another.
- Administration setback – this is setbacks in relation to discipline time and administration setbacks.
- Site congestion – there is a difference between a site being overcrowded due to a large number of artisans on site because the project is a large job, and a site being overcrowded because of many tradespeople on the job to finish it on time.
- Altering supervisors – this means changing supervisors from time to time and from site to site according to job needs. In addition, some supervisors resign on their own for a better job, better position or financial reasons.
- Working additional time – some studies stated that working overtime creates too much stress and fatigue for the tradespeople and staff and leads to productivity loss.
- Climate circumstances, for example, temperature (hotness or coldness), humidity, and severe cyclical circumstances; the extent of temperature and humidity are usually considered vital in working surroundings because they have great effects on construction productivity.

The construction industry in Australia is still a considerable player in Australia's growth. The construction industry is driven by two factors, the number of recruited staff and economic growth. Regarding the input to GDP, construction fell to 6.8% in 2008–2009, its minimum rank since 2005–2006 and first reduction since 2000–2001. Considerable investment in architectural projects and financial issues touching construction works have seen the value of construction work completed in 2008–2009 nearly equally divided between these two factors (the number of staff and economic growth). In 2004–2005, construction and architectural construction works provided

62.7% and 37.3% respectively. Recent construction industry–related media coverage has focused on the effects of the GFC, government infrastructure spending, and housing availability (Australian Bureau of Statistics 2009).

Regardless of the reduction to GDP in 2008–2009, the recruitment in the construction field has increased since the past. Over the last few years until May 2009, the rate of increase in weekly salaries in the construction industry was 13.7% faster than the salary increase rates in other industries. In the same period, the number of hours worked was higher than in other industries and business at 12.2% as of May 2009. The construction industry is still the highest among Australia's industries because it is the largest, the most successful and the largest provider to the GDP, with activity in industry index frequently precisely connected to alteration in social, economic, and political trends (Australian Bureau of Statistics 2009).

2.21 THE EFFECT OF THE SHORTAGE OF SKILLED LABOUR ON CONSTRUCTION PRODUCTIVITY IN AUSTRALIA AND THE USA

The shortage of experienced construction tradespeople and artisans in the USA and Australia has a deep and longstanding history; from time to time, it is relieved slightly, for example in a time of recession, but it could become worse as time goes by. The deficiency in skilled labour is caused by many factors, for example, varying from a bad image of the industry and low pay to bad site conditions and unstable careers. The only ways to improve the industry image are encouragement and salary increases, but these are hard to manage unless the industry has an inclusive program to support the system.

The construction industry has a rating or classification system like any other industry; sometimes these ratings or classifications are official and other times they are unofficial. They describe and classify construction firms from the viewpoint of size and ability to carry out specific types of projects; for example, tier 1 firms are the biggest, richest, and most highly experienced in the construction industry and carry out the giant projects; tier two firms are most likely to carry out commercial projects (more than residential projects); and tier 3 firms take on the smaller projects, usually around the million-dollar value.

There is a strategy to improve two tiers of the workforce, tier one and tier two in the US construction industry. Tier two is designed to increase workers' skills and productivity, creating a situation whereby the value of the workers is increased. The object of this increased value is increased wages and more stable careers within the construction industry (Construction Industry Institute 2004). In addition, tier 1 is designed to easily administer an actual labour force, regardless of its experience level. The focus is on the management system, communication, and exercise in the area of management. The tier one approach is an old idea and has been adopted to create a comprehensive administration style to concentrate on workforce administration. It gives priority to labour skills, management, communication, and preparation at all stages. The technique uses metrics to scale the level of operations of some factors of the technique, but do not authoritatively specify the method of operation. Five indices comprise the metrics: project average work skills, information technology utilisation, technique utilisation, projects communication, and management forms. The two approaches are characterised by metrics that measure the degree of implementation. The metrics symbolise the perfect goal of the approaches without prescribing the procedures of implementation. Both the tier I and tier II exercise metrics must be proven and refined applying baseline information to enhance (Construction Industry Institute 2004).

As mentioned above, the construction businesses is a great resource of the US economy; the value of the construction works created in 2000 was over $800 billion (US Census Bureau, Statistical Abstract of the United States 2001). The impact of construction productivity in regulating the expenses of a project and reconstructing the productivity of the construction worker will result in a great saving in the expenses of the construction projects. The Construction Industry Roundtable (CIRT) in the present time is studying and researching deeply the factors affecting the American construction businesses and how to overcome and eliminate them. The results of this study will represent very inclusive examinations of the USA construction productivity complications ever attempted (Construction Industry Institute 2004).

The construction industry is the largest industrial recruiter in the USA. The construction industry annual turnover reached 10% of GNP. However, starting from 1975, the building/construction industry has reduced to less than 8% of GNP. This reduction in parallel with the US economy reflects apprehension in a country with a lot of disused industrial units, disintegrated cities and towns, non-existent or collapsing transportation systems, and an uncertain power system. Further, the building/construction industry faces work rate difficulties more serious than does the entire economy (US Department of Commerce 2001).

A high level of productivity in the construction business, given both the significance of productivity on GNP and the effects of high productivity, is essential to a better economy in the USA. The Construction Industry Roundtable (CIRT) started its study of that industry some time ago. The US Department of Commerce (2001) stated, If the recommendations from this study are implemented, even to a moderate degree, there could well be savings of at least $10 billion per year.

Both the research of the CIRT along with its suggestions and approvals about the factors and obstacles affecting construction productivity and how to eliminate these are due to become available soon. At the same time, the CIRT announced its Phase I study, which will sketch the extent of the project and the methods for carrying it out. The CIRT report is subdivided into five main parts (Construction Industry Institute 2004):

- Project management
- Construction technology
- Labour effectiveness
- Labour supply and training
- Regulations and codes

Beneath every item of these investigation parts are a number of issues to be discussed. The CIRT has classified construction productivity complications into phases as follows:

The Phase I study explores some critical factors affecting productivity in the construction industry, problems that currently greatly hinder cost-effective construction. Although that analysis is only preliminary, it does, nonetheless, raise a number of thought-provoking points (Author). The following highlights some of the problem areas briefly discussed in that Phase I study. In a word, this is intended to be a narration of what appear to be the most important problem areas concerning construction productivity (Heizer & Render 1990).

2.21.1 Improvements

Enhancing and developing construction industry administration is urgent. As stated in the CIRT Phase I report, not all is well with construction industry management. Actually, poor administration processes are the main factor causing poor productivity in construction. Many of the mechanisms that need to be completed to improve productivity, including better planning, management that is more effective, improved job procedures, better communication and more effective manpower and personnel policies, are dependent on management. Over half the time lost in construction stems from poor management practices (Construction Industry Institute 2004). In keeping with this finding, one reason that construction productivity continues to decline is that management has failed to pay attention to its own shortcomings (Construction Industry Institute 2004).

2.21.2 Safety on the job site

Presently in Australia, the number of injuries and deaths in the construction industry is at an unsatisfactory level (Dingsdag, Sheahan & Biggs 2006). Regardless of comparable kinds of labour measures, technology and artisan workers, one of the factors in unsafe conditions on work sites are the lack of safety standard administration. One more reason, the labour force factor, is that the workforce is temporary, not permanent, because the construction industry usually depends on a limited crew of permanent staff from the main construction companies and a major number of personnel and subcontractors from different-capacity contracting firms.

The representatives of the CRC for Construction Innovation subsidised an investigation into the efficiency of creating national standard safety capability through the Australian construction industry for standardising safety procedures and also for recognising the importance of the following safety act (Dingsdag et al. 2006). A second factor leading to sub-optimal safety accomplishment discovered by the study group is that Occupational Health and Safety (OHS) management is urgently needed in Australian administration. There are nine essential OHS deeds, and those nine deeds are concentrating on and imposing compliance, instead of contributing to an essential education and training program, which is achievement-based and dependent on self-requirement (Sheahan, Biggs & Dingsdag 2005).

Unsafe workplaces and construction sites are a strong factor that affects construction productivity. Workplace injuries have a great influence on the project budget, for example, the cost of medical expenses, legal action cost, delay in the project schedule, and rehabilitation and re-training expenses. Safe Work Australia has estimated the cost of work-related hurt/harm as $57.5 billion dollars in 2005–2006 or 5.9% of Australia's GDP (Australian Bureau of Statistics 2007–2008, National health survey).

In the USA, more than 11 million male and female workers comprise the workforce for the building/construction industry (Bhattacharjee, Ghosh & Young-Corbett 2011). Construction work sites are complicated because of subsequent work development, the advanced technology used, workers' lack of experience with equipment, and their knowledge of site safety. The number of occupational casualties in the building/construction industry is exceptionally high (Bhattacharjee, Ghosh & Young-Corbett 2011).

In 2002, the total (direct and indirect) cost of casualties and non-fatal accidents was US$13.00 billion (Bhattacharjee, Ghosh & Young-Corbett 2011). These statistics indicate the significance of health and safety in the building/construction industry.

2.21.3 Construction management systems

In the present time, construction businesses are urgently in need of broadening their use of modern technology and new construction administration styles to be in parallel with new sophisticated lifestyles. The revolutionary use of the modern administration styles and techniques leads to better design, preparation and scheduling, acquisition, expenses, material coordination and character affirmation. Computer use is compulsory for managing and controlling the construction industry.

This is highlighted by the fact that the construction industry has been criticised for its poor performance in delivering major projects on time and within budget. As computer applications become more available, both technically and economically, construction project managers are increasingly able to access advanced computer tools capable of transforming the role that project managers have typically performed. Competence in using these tools requires a dual commitment to training from the individual and the firm (Cox & Hampson 1998).

Improving the computer skills of project managers can provide construction firms with a competitive advantage to differentiate themselves from others in an increasingly competitive international market. Yet few published studies have quantified the existing level of competence of construction project managers. Identification of project managers' existing computer skills is a necessary first step to developing more directed training to better capture the benefits of computer applications.

In addition, the checks and balances previously available through competitive bidding have all but disappeared from the contracting of major utility and industrial projects. In its place are most often cost-plus-fixed-fee contracts. Failure to meet schedules and large cost overruns are largely because of the construction industry's inadequate management control systems.

2.21.4 Risk management in the building and the construction industry

The construction clients are in need of assistance with managing the possibility of the construction project's risks within specific areas such as legal aspects, economic/finance, working approaches and bureaucratic problems. Recognizing severe risks through the early stages of the building tasks could help in avoiding extra costs, delays, and interruptions. The risk examination/analysis and management procedures require recognizing construction risks and planning a useful risk management approach to diminish the possibility of crisis' during the project execution stages and in the future.

Risk management assists the project owner to identify and control the risk during the whole of project phases starting from designing/engineering and construction stages to the finishing point.

In the present time, the construction and building projects have increased in competition; as a result, the weight of risk involved for proprietors, construction firms, architects, consultant engineers, financers and financial organizations increased the possibility of adverse effects on projects. The risk management team recognize and supply itemized and inclusive analysis reports on the possibility of project effects through the following approaches:

a) Risk Management Approach

- Risk Reproduction and Examination
- Critical Path Method (CPM) Timetable Analysis
- Measuring Anticipated Values and Shaping Risk Outline
- Reducing Risk Dislike/Aversion

b) Risk Management Evaluations

- Agreement and Spec Requisites
- Review of the Buildability/Constructability
- Financial planning and total project cost
- Speeding up the Construction's Schedule
- Shuffle/Change Order Recognitions and Authorisation.
- Inquire for Data Evaluation (IDE)
- Construction Technique
- Deferment and Interruptions
- Damages/Losses Evaluations

Achieving the goals for any construction project in terms of time and schedule, cost, safety, characteristic and circumstantial sustainability is dependent upon the risk management, which is considered as a highly substantial management procedure.

Most researchers have concentrated their works on factors of construction and building risk management instead of using a comprehensive and an efficient approach to identifying risks and examining the possibility of happening and the effects of those risks.

Researchers have found many risks developed through the entire project stages; some of those risks occurred more than once in the same stage in the same project. In addition, these studies concluded that proprietors, architects engineers, government departments and other parties involved in the construction project should work jointly starting from the early stage to identify severe risks in time to arrange for achieving safe, effective, and quality construction tasks (Flanagan & Norman 1993).

An efficient approach to risk management has been subdivided into the following:

- Risk classification,
- Risk identification,
- Risk analysis
- Risk response

On the other hand, the risk response has been branched into four sub-branches as follows:

- Retention risk
- Reduction risk
- Transfer risk
- Avoidance risk

(Enshassi et al. 2014)

A productive risk management approach could assist comprehending what type of risks is confronting and how to overcome those risks in various stages of a task/project. Nowadays, because of the increase of the significance of risk management, it has been identified as an essential in many of the industries. A number of methods have been advanced to control the effects created by extreme risks (Schuyler 2001; Baker & Reid 2005).

A questionnaire survey could be used to gather essential and critical information about the risks in any construction project/industry. The questionnaire survey results could be managed and analysed by using the statistical package for social science (SPSS) or any suitable statistical program (Ruppert 2011). The outcome results obtained from the survey should be confirmed or validated by using a Delphi survey or any other acceptable methods or technique. There are some numbers of aspects in construction risk; for example, an extreme risk is that some construction companies could go bankrupt due to project collapses or the project being located in isolated areas far from urban areas (Bhattacharjee, Ghosh & Young-Corbett 2011).

2.21.4.1 Risk assessment

Risk evaluation/assessment is the comprehensive procedure for risk recognition/ identification, risk analysis, and risk judgment/evaluation. (More information on risk evaluation technique is on ISO/IEC 31010).

2.21.4.2 Risk recognition/identification

The construction institution should recognize the main source of risks, the spots of effects and collisions, circumstances and its origin and its serious outcome. The purpose is to create an overall record of risks based on these circumstances, which

could create, improve, avoid, diminish, speed up or stop the accomplishment of productivity. It is necessary to recognize the risks associated with the tasks to implement appropriate solutions but not to pursue a chance/opportunity.

The construction institutions should implement risk recognition means and techniques, which will suit the construction productivity and to the risks confronted. Relevant and most recent data and the information is mandatory in recognizing risks. Staff and skilled professionals with suitable experience should participate in recognizing risks (Sheahan, Biggs & Dingsdag 2005).

2.21.4.3 Risk analysis/examination

Risk analysis engage an advance understanding of the risk; it helps in assessing the risk and if it needs treatment and deciding upon the right technique to be used. Tasks that affect the results and its possibility must be recognised.

The excellent skills in deciding the degree of risk and its potential to conditions and expectation should be thought out in the analysis, and conveyed adequately to decision makers and shareholders. Tasks such as diversity in experts' opinion, ambiguity, availability, characteristic, quantity, and data should be declared and illuminated (Sheahan, Biggs & Dingsdag 2005; Bhattacharjee, Ghosh & Young-Corbett 2011) .

2.21.4.4 Risk assessment/evaluation

The goal of risk assessment is to help in making decisions, depending on the results of risk analysis, for that risks need treatment and the preference for treatment implement.

Risk assessment or evaluation is needed to measure the degree of different risk found during the analysis/examination procedure with risk criteria. Depending on this measurement, the required treatment could be decided.

2.21.4.5 Risk treatment

Risk treatment means selecting the suitable number of choices for alternating risks, and carrying out those choices.
Risk treatment follows a periodic procedure of evaluating a risk treatment; determining if the remaining risk levels are acceptable or creating an alternative risk treatment; and evaluating the impact of that treatment.

Risk treatment choices include the following: -

a) Do not start the task to avoid the risk.

b) Eliminate the risk main source.

c) Changeful of the possibility.

d) Changing the results.
e) Consulting the risk with other groups such as contracts and financing institutions.

In this research, from the two surveys (principal survey and Delphi survey) conducted to a number of the project managers and experts in the construction industry, it is found that there are some risks involved in the construction industry in Australia such as rework, incompetent supervisor, incomplete drawing, lack of material, work overload, poor communication, poor site condition, poor site layout, overcrowding, inspection delay, absenteeism, worker turnover, accident, tools /equipment breakdown, and lack of tools and equipment. Some of these factors have severe effects on the productivity; other some have moderate effects, and the rest of the factors have low impact on the productivity. The following two or three factors out of the fifteen factors representing not only critical success factors in the construction industry in Australia but also risk factors on productivity.

- **Rework**

It causes the project heavy financial costs and schedule delay for redoing or rectifying the defected work; these overrun costs represent a risk to the project budget. The cost to project's budget is almost and around 5% of the total construction costs and it can hold the project back from progress (Hwang 2009; Enshassi et al. 2014). To eliminate the rework problem from the building tasks, the project manager should hire skilled artisans and very experienced supervisors to look after the work and the workers. In addition, the construction companies should run training courses from time to time during the working year.

- **Accidents on the construction site**

Construction sites are the most dangerous place to be, therefore hardhat must be used. The majority of the construction organizations are doing their best to protect their staff from accidents, but if the work involved an assembly of a large structure, the danger could take place. Equipment and tools, truss and large trucks are all presenting threat on the construction work sites. On the other hand, the development in the construction industry has created high competition among the contractors and construction firms that are carried out at the cost of the artisans' interest, their health issues and their safety on the site. Accordingly, realising the causes of and the impact of accidents on building sites is very essential (Dingsdag, Sheahan & Biggs 2006). Suggesting some approaches of how to reduce these accidents from the first place should be seriously considered. In order to study the accidents problem on sites (Sheahan et al. 2005), it is recommended to use risk management software program such as risk package. This

Industry of workplace	Total deaths 2016	Deaths 1 Jan 2016 to 5 Jan 2016	Deaths 1 Jan 2017 to 5 Jan 2017
Transport, postal & warehousing	64	0	4
Agriculture, forestry & fishing	41	3	1
Construction	30	2	1
Arts & recreation services	8	0	1
Electricity, gas, water & waste services	7	0	0
Mining	7	0	0
Other services	4	0	0
Administrative & support services	3	0	0
Manufacturing	3	0	0
Public administration & safety	3	0	0
Information media & telecommunications	2	0	0
Accommodation & food services	1	0	0
Education & training	1	1	0
Health care & social assistance	1	0	0
Professional, scientific & technical services	1	1	0
Retail trade	1	0	0
Wholesale trade	1	0	0
Government administration & defence	0	0	0
Financial & insurance services	0	0	0
TOTAL WORKER DEATHS	178	7	7

package will help in identifying where is the risk, analysing the risk and how to treat the risk (Bhattacharjee, Ghosh & Young-Corbett 2011).

Most of accidents on the building site are mainly due to negligence, unreliable tools and equipment, unskilled trades, incompetent supervisor, site condition and site layout; usually workers and artisans are the most people are affected by site accidents. Accident also causes many delays in project completion (Kadir et al. 2014). In Australia and United States of America, although the construction industry is safer than ever but it is still a dangerous industry (the author). In Australia alone, the construction industry fatality in the year 2016 reached thirty peoples and all other industries reached the 187 death cases (Safe work Australia 2017), Table 2.11.

Table 2.11 Preliminary worker deaths by industry of workplace in Australia (2017)

Source (http://www.safeworkaustralia.gov.au/sites/swa/pages/default

The Bureau of Labour Statistics (BLS, USA) reports 775 deaths at construction sites in 2012. This represents 19.6 percent of all workplace deaths during that year. The most common causes of accidents at construction sites as reported by BLS and The Occupational Safety and Health Administration (OSHA) could be concluded in the following:

Falls objects kills 278 persons, which represents 36% of the total deaths in the construction industry.

Struck by foreign objects kills 78 person, which represents 10% of the total deaths in the construction industry.

The Occupational Safety and Health Administration reports the most common

violation of USA federal regulations involves protection from falls. Communication systems to warn workers of hazards and inadequate safety on scaffolding.

Many others workers were killed by "caught in-between" accidents were workers died after being caught between two objects.

A number of workers killed by electrocution, which resulted in 66 deaths. That number was 9% of total fatalities at construction sites.

Falling debris and tools are common at construction sites; unfinished plumbing and electrical work always causes Fire and explosions.

Construction trades are working long and hard hours, which causes tiredness, which can create an accidents and deaths.

Cars and trucks accidents are also a common cause of accidents on construction sites.

Trenches, dug to run pipes and wires, will sometimes collapse, bringing machinery and vehicles down on top of trapped workers.

To provide site safety and to minimise the accidents from happening repeatedly the project management firms must implement a safety policy, using on site safety means (equipment and tools), enforce training programs on safety rules and accident avoidance methods.

Construction firms should initiate the first step to hire consulting companies specialised in risk management in order to communicate and transfer a variety of risks. In addition, construction companies should use the computers and risk management software to analyse and assess the risks in any task or project for example, risk package that is completely compatible with some programs such as Microsoft Excel and Microsoft Project. Overall, the risk management technique can help the project managers to recognise the impacts of rework, its sources, and accidents. By eliminating or reducing the reworks and accidents on the construction sites, the construction industry productivity, project cost, and working schedule will be improved totally.

2.21.5 Supervisor performance

The supervisor plays a very important part in the construction site and if they have enough experience and training, they will get very effective use of labour. Normally, skilled supervisors come up from the ranks, yet when they make the transition to supervisor, there is no formal training to assist in planning, scheduling, cost control, or strategies to motivate construction workers.

2.21.6 Contracting practices

Construction contracting practices are becoming more complex, resulting in added costs to owners and contractors. Two key concerns here include the declining use of competitive contracts and the increasing amount of litigation stemming from contract risks and liabilities (Oyegoke 2001).

2.21.6.1 Construction research and development

In the USA, the construction industry suffers cost overruns due to failure to use the new sophisticated technological advances (Arditi & Mochtar 2000). On the other side, many advanced and industrialised countries have more progressive construction industries; Japanese construction contracting firms, for example, have significant in-house Research and Development (R&D) programs, assigning 80% to 90% of their R&D budgets to support primary research and field problems. Vital to increasing the level of R&D in the American construction industry is the owner/user of construction services: these clients could act as a catalyst to promote technological innovation. At the moment, the main reason for the low rate of technological innovation is the lack of demand. Furthermore, technical standards and codes, special interests and legal considerations inhibit the demand for new technology. In this environment, innovation is penalised rather than rewarded. Yet there are some forces at work that may impel the US construction industry to pay more attention to R&D in the years ahead: the cost competitiveness introduced by the open shop; and competition from foreign companies in both world and US markets. At the moment, US contractors essentially do no R&D, which is holding the field back. Consequently, the USA does not lead in any construction field. Furthermore, US firms have been slow to adopt advanced foreign technology. The upshot is the possibility of an erosion of home markets to foreign competition (Holt 2014; Arditi & Mochtar 2000).

2.21.7 Productivity of construction workers

There is great promise for enhancing the productivity of construction labour. Only one-third of a construction worker's time is spent in productive work. Moreover, the productive hours are often less efficient than they could be. Improving worker productivity calls for better project management, better training of workers, and the use of labour-saving tools and techniques (Rojas and Aramvareekul 2003 a).

2.21.8 Craft union jurisdictional rules

The belief that each aspect of work lies within the absolute authority of a specific craft has long been a source of disagreement and incompetence in union construction work. Certainly, a substantial portion of the work falling within the jurisdiction of each craft is also within the capability of other expertise. Needlessly accurate managerial lines often limit the customer's selection of builders and the contracting firm's capability to assign work thoroughly. They also restrict creative methods and the advancement of new technology. Contractor efforts to avoid jurisdictional problems result (Holt 2014; Arditi & Mochtar 2000).

2.21.9 Extra overtime work could affect negatively productivity

Overtime is always preferable to both the proprietor and the construction workers. The proprietor will pay a small amount of money in overtime compared to the money spent in hiring new crew to speed up the construction activities, and from the workers' side they will get more money in the pocket, although this will affect disorganization of other work on another project. The bad effect of working overtime is that it will exhaust the labour's capacity where workers extend their work beyond forty hours per week. Consequently, overtime affects construction productivity.

2.21.10 High absenteeism and turnover

In the construction industry, absenteeism from the workplace and turnover are a lot higher than in most permanent and reliable industries. This type of outcome expands the preparation and coaching expenses, and makes for a varying workforce, ineffective preparations by supervisors and impoverished staff self-esteem. All these factors cause low productivity and delays in the project schedule. Productivity researchers in the construction industry hope to identify all the projects that lead to absenteeism and turnover and to discover the ways to prevent or at least minimize those percentages (Chancellor 2015; Jiukun, Goodrum & Maloney 2007).

2.21.11 Greater use of trainees and helpers

The union sector of the construction industry has not made as effective use of trainees as has the non-union sector. Among the reasons for this are the fact that workers are unwilling, in general, to include such a category in agreements with contractors; also contractors' ineffective use of such trainees; and inflexible attitudes on the part of management and labour. Researchers in the construction industry need to identify the pros and cons of using trainees and develop recommendations for their most effective use (Author).

2.21.12 Involving vocational schools

At present, vocational training facilities in secondary school, TAFE, some colleges, and university stages are mostly applied to prepare artisans in the construction industry. In the union sector, workers have traditionally been trained by the apprentice system, jointly administered by the contractor and the craft union. A strong belief exists that the Australian vocational education system could play an important role in training workers for the construction industry. One reason is that during downturns in the economy, apprenticeship programs tend to flounder, as both contractors and unions are reluctant to push these programs when skilled artisans are looking for work (Author).

2.21.13 Inadequate information on the availability of skilled workers

A good database for skilled construction workers is very difficult to find anywhere. This causes many difficulties in making accurate estimates for project timetables or setting up work schedules for given projects. Researchers in the construction industry are hoping to decide which specific workforce information, if available, would be helpful in planning industrial construction projects.

2.21.14 State and local building codes

Although most of the local building codes in the USA are based on one of the four major model codes, local revisions and frequent omissions of up-to-date revisions lead to substantial diversity. This variety of codes sometimes causes problems for firms operating in more than one geographic area. It also impedes innovation, which fragments the market, discouraging the development of new products and processes. Other code problems stem from poor code maintenance, delays by building inspectors in making inspections at job sites, and inadequately trained building officials. Sometimes, code administration and enforcement at the local level suffer inconsistency and delay, resulting in unwarranted costs. Furthermore, the inspection process often contributes to major delays, for example, stoppages caused by the need to wait for an inspector to visit a construction site; inspectors leaving after citing minor violations that could be corrected on the spot, thus requiring a follow-up inspection; and having several inspectors from different agencies inspect the same item.

2.21.15 Other key points

The lack of adequately trained personnel in building departments is a major factor negatively affecting the entire code administration and enforcement process. Their lack of educational qualifications and professional status contributes to conservative judgment, inability to deal with technical code provisions and susceptibility to political influence. Concerning the area of permits, the construction industry's major complaint is not with the need for a permit itself, nor even the associated fees. The problem lies in the frequent permit renewals and the number of similar permits needed for the same project (Bandow & Summer 2001).

In many cases, building codes dictate which materials must be used. This causes great effects on construction costs and could be overcome by the use of performance standards. Performance standards focus on objectives, rather than locking the designer into possibly obsolete methods, materials and procedures, yet performance codes are more difficult to apply and require more expertise on the part of the building official (Bandow & Summer 2001).

2.21.16 Motivating construction workers

The construction industry has a low self-image among the other industries, especially the manufacturing sector, because the majority of construction workers consider it an unstable industry and a temporary job; also, there are many risks involved on site.

Moreover, in many cases, the ineffectiveness of construction workers on a given site stems from their lack of motivation and their inability to identify with the goal of their employer (Author).

2.21.17 Measuring construction productivity and construction improvement

The productivity-recorded data of the manufacturing industry is well organized and well documented for its dependability and trustworthiness; but the opposite is true in the construction industry because it lacks the required reliability and credibility. Therefore, there are some trials to initiate and create a nationwide construction productivity registry organization for characterizing, accumulating, assessing, and distributing productivity data. The construction industry urgently requires a method for measuring productivity (Malisiovas 2014).

2.21.17.1 First – measuring productivity

Productivity data is usually stated in terms of average productivity. Assuming average weather, an average number of delays, average working conditions and so forth, contractors may use records to predict their activity productivity. Faced with extreme conditions, contractors may revert to the use of index numbers to predict activity productivity. These index numbers adjust average productivity by weighing its value

as a function of non-average conditions (Adrian, 2002).

Productivity measurement is important and needs to be improved. It determines the level of productivity and the appropriate corrective actions. Appropriate construction productivity measurement helps owners and contractors to:

- Decide an effective way to manage the project.
- Distinguish conflicting flow fast to carry out the right action.
- Decide the impact of the alteration of procedure or circumstances.
- Recognise the high and the low spots of the productivity curve and to find out why there are differences.
- Appraise the achievements.
- Supply an assessment to designers and estimators.
- Start a technique for productivity enhancement.
- Compare the performance of different projects.

2.21.17.2 Second – productivity improvement

Productivity in building/construction is often generally outlined as output per labour hour (Hendrickson, 1998). Since workers form a significant part of construction expenses, the number of labour working hours in achieving a project in construction is more susceptible to the influence of management than are material or capital. This productivity scope is often referred to as labour productivity. Nevertheless, it is essential to observe that labour productivity is within the scope of the overall influence of a performing system in utilising labour, equipment, and capital to change labour work into valuable output, and is not a scope of the capacities of labour only. For example, by investing in a piece of new equipment to carry out a specific project in construction, output may be expanded for the same number of labour hours, so the result will be higher labour productivity (Sveikauskas et al. 2014).

This is another definition of labour productivity: it is a ratio of the progression at which inputs, for example, workers, assets and unprocessed components, are converted into outputs. The productivity rate could help some construction companies, businesses, and economics. Productivity progress means that lesser inputs are used to produce a given output or, for a given set of inputs, more output is produced.

Productivity advancement is necessary for economic development and better living standards. Regarding the contributions of societies, partnership, and the capacity for the increase in GDP per capita over the last thirty years in Australia, it has been clearly proven that productivity is the main foundation behind most of the growth in the national income (Figure 2.7). Productivity remains the backbone of the Australian economy and the effective source of living standards. Therefore, working hard on developing and enhancing productivity in general and construction productivity in particular is highly recommended. Productivity enhancement is mandatory in assisting Australia in facing future problems such as the ageing workforce and climate change.

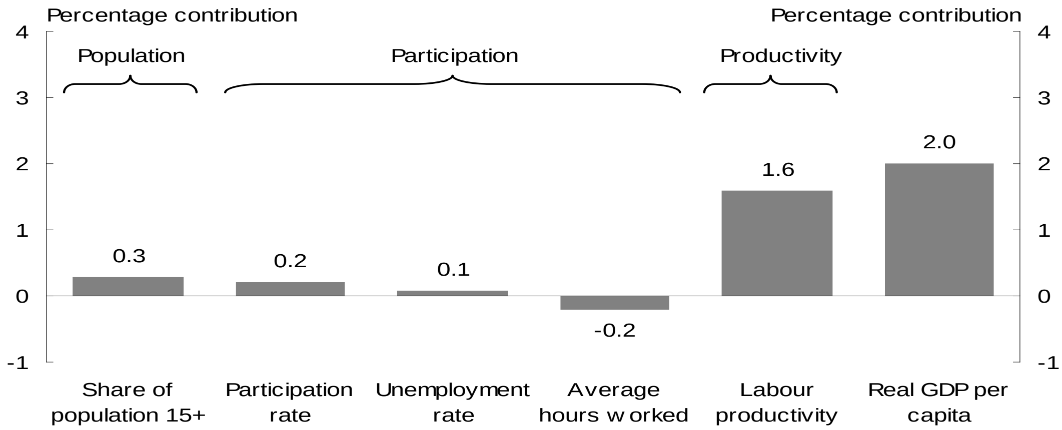
2.21.17.3 Third – the benefits of improving productivity

Improving productivity will have a good impact on both the client and the construction contractors, as follows (Australian Bureau of Statistics 1977–1978 / 2007–2008):

- client

    - lower costs
    - shorter schedules
    - higher return on investment
- contractors
    - increased profit ($)
    - higher projects turnover
    - more competitive edge (refer Figure 2.7).

Figure 2.7 per annum growth in real GDP per capita, 1977–1978 to 2007–2008



Source: ABS 1977-78/2007-08 cat. No. 5206.0, 3201.0, 3105.0.65.001

Productivity improvement branches out from multiple sources. These sources could be an objective and high-tech approach that supplies new commodities and actions, the transformation and dissemination of modern commodities and procedures, or a modern administration system, bureaucracy and work plans. In recent years, information and communication technology (ICT) has played a very important part in modern techniques for improving productivity where companies have embraced ICT, then enhanced their production procedures. Productivity enhancement can be due to approaches initiated in Australia or from overseas (Australian Bureau of Statistics 1977–78/2007–08, cat. No. 5206).

The general tactical framework usually plays a critical part in carrying out productivity improvement, because it influences the surroundings where companies do business. Tactics are necessary in order to enhance the capability of assets used in the economy. This can help well-operating markets, cut out misuse, and improve adaptability, openness, and animations at the level of the company and the sole trader. In addition, tactics could enhance surroundings in which workers and companies have the encouragement and the capacity to use opportunities to advance productivity. Addressing the marked lack of success in the areas of infrastructure, modernisation, and human capital would also supply a substantial path for productivity gains (Australian Treasury Report 2009).

2.22 PRODUCTIVITY MEASUREMENT AND IMPROVEMENT IN THE CONSTRUCTION INDUSTRY IN THE USA

The construction industry represents a significant constituent of the US economy; construction productivity in the US has dropped for some time. Because of the absence of measurement procedures, the significance of the low work rate or the work capacity complications in the US construction industry is generally unknown. To discuss these inadequacies, great efforts are taking place now focusing on the measurement of construction productivity at three levels: project, project and industry, and how such measures can be advanced, in what way or manner they are connected to the benefit of information and mechanisation technologies and construction methods during project life spans, and how to construct a number of projects or projects at one time in order to develop the competence, ambition and modernisation of the US construction industry. At the same time, it is necessary to recognize the factors that have heavy effects on improving the productivity of the US construction industry over the next few decades. These actions involve, but are not restricted to, interoperable technology use via building information modelling (BIM) and adequate achievement measurement to drive effectiveness and modernisation (Huang et al. 2009).

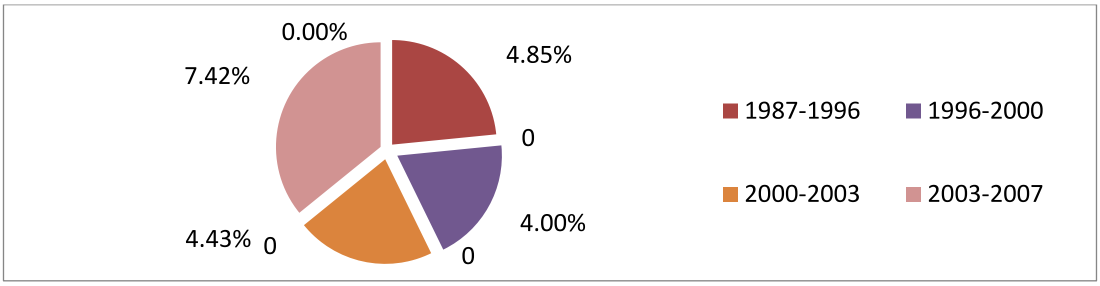
Currently, the construction industry has an acceptable standard for weighting construction work productivity. The American Society of Testing and Materials International (ASTM 2016) embrace a fresh standard for measuring construction productivity as stated before at project, project, and industry levels. The new standard, (ASTM E-2691-2016), is a speedy method for absolute weighting of productivity that depends on valid recommendations from the construction site for weighting the construction works established in place and indicates the gains or losses in productivity promptly. The standard is called job productivity measurement (JPM). In addition, JPM weights the alterations of the proportions of productivity at the same time that it's weighting the work advancement.

The American ASTM E-2691-2016, known as JPM, measures building/construction productivity regularly and persists in advising project stakeholders about productivity changes. By measuring construction productivity changes at the project, project and industry levels, issues can be resolved early enough to reduce waste and minimise errors. The use of this standard will hopefully lead to an elevation of construction productivity on a par with other industries. The purpose of the standard is the urgent need for productivity development in the construction industry. What gets measured is managed, outside regulations and exact and accurate assessment. The construction industry has experienced many difficulties for decades. Generally, the USA has appreciated the greatest productivity increases in the workforce if it is compared with other nations (Abdel-Wahab & Vogl 2011).

Table 2.12 US productivity levels over 20 years 1987–2007 (annual growth rate)

Years	Manufacturing Productivity	Construction Productivity
1987–1996	4.85 %	2.90%
1996–2000	4.00%	2.79%
2000–2003	4.43%	3.83%
2003–2007	7.42%	3.58%

Figure 2.8 US productivity levels over 20 years 1987/2007 (annual growth rate)



The national growth in productivity of all industries is not reflected in the construction industry. According to the US National Institute of Standards and Technology (NIST), the construction industry is a significant contributor to US growth, although its contribution to national productivity level lags by ten times the national average.

JPM recognises the productivity flow of the complete activities; likewise the site reaction to particular expense codes. The diagrammed productivity flow is typical of the activity, enabling managers to anticipate and oversee the labour productivity variation from the site perspective. This awareness of the activity supplies a technique for managing labour productivity variation and eventually for administering the connection between labour productivity and job expediency. (Table 2.12 and Figure 2.8).

The JPM methods start with the improvement of ordinary language, a defined cost-code system of high-level activity codes. These cost codes must be applied all the time on all projects. If a construction firm has various divisions working on other kinds of projects, it needs to apply a various number of cost codes. Nevertheless, each division or department in the firm must be restricted to 15 to 20 codes, and out of this sum just 7 to 10 various codes must be used to clarify any job.

JPM starts at the beginning stage of a job in any project with the improvement of the work breakdown structure (WBS), which converts the work from the estimate stage to the site basic standard or level working hour budget. At the beginning, the project preparations committee separates the work into the cost codes relating to the kind of work being done, and constructs an effective WBS of the main action on the construction site. These WBS also involve actions from the construction site side, which were not planned at the time of the assessment.

JPM is now an accepted system for weighting construction productivity by weighting the work done correlate to the construction produced. JPM weights features of the construction outcome by weighting the noted achievements of the project as approved by the client. Using this method minimises the demand for job completion inspections on construction projects by supplying continuous and intermittent assessment of mistakes, fixing, and rework. All these problems will be settled as soon as they surface during periodic examinations with JPM.

By measuring productivity and its variations through construction projects, complications can be recognised and solved fast, resulting in good productivity on job sites. Construction firms and contractors which implement JPM tracking records enhance their cash flow and profitability (Daneshgari & Moore 2011) .

2.23 THE DIFFERENCE BETWEEN PRODUCTIVITY AND PRODUCTION

A widely misunderstood idea in the construction industry is the dissimilarity between productivity and production. Because of the bookkeeping standard familiar to managing firms, most calculations of work productivity are bookkeeping calculations of production, and not calculations of productivity. The current procedures claiming to measure productivity generally concentrate on accounting measures, for example, earned value analysis (EVA), and lack the capacity to report continuous actions on the work site in order to take immediate action to lead to enhance productivity. Bookkeeping procedures are generally reporting of significant or financial worth measures, and provide no facts for developing productivity of the construction works as it progresses.

2.24 INTERNATIONAL LABOUR PRODUCTIVITY (A BRIEF LOOK FROM THE OECD 2012)

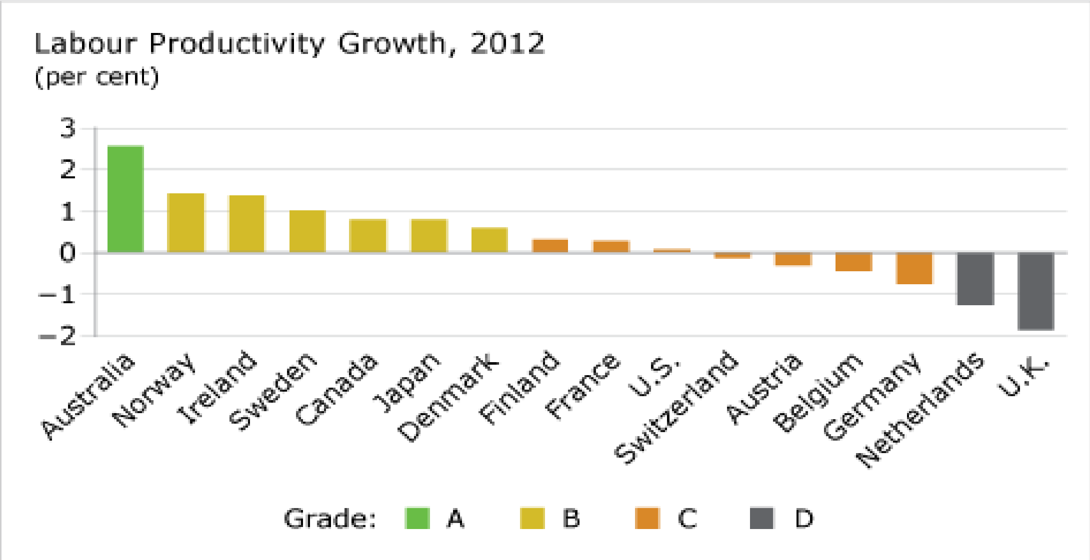
Productivity in general is an essential element of a population's per capita income over a long period. In order to adapt better to developing technology and make use of new improvements and modernisations, The Organization for Economic Cooperation and Development (OECD) countries are hopefully seeking greater productivity, as stated by the economic think tank, the Conference Board of Canada. Nevertheless, productivity is frequently hard to measure because of the periodically of workers' markets, and also the extent of subjective and measurable projects that can be considered for evaluating productivity, for example, the time that has been taken to create procedures, and in addition by the dependability of data on labour hours. The OECD countries have seen a slow drop in workers' productivity growth from 2004 to 2009, with the most critical years of the crisis, 2008 and 2009, experiencing reductions of 0.1% and 0.3% respectively. This started to improve again in 2010 and workers' productivity is beginning to recover with a gain of 2%, and in 2011 with an extra 0.8% gain.

Labour productivity varies from one country to another because it is not improving in all places; for example:

- In Greece, the European nation most struck by the severe deficit problem which is sabotaging the progress and accomplishment of the European nations, workers' productivity continues to decline, decreasing by 2.8% in 2010 and an additional 0.9% in 2011 after poor achievements in both 2008 (–1.5%) and 2009 (–0.3%) respectively.

- US workers' productivity decreased in 2008 by 0.7 %, rose in 2009 by 2.1% and in 2010 by 3% before slowing again in 2011 by 0.6%.
- In the Russian Federation, productivity turned to the bright side in 2010 by 3.8% and also in 2011 by 4.2%, after a significant fall by 5.2% in 2009.
- Russia and Mexico were the best two countries in productivity performance in 2011 by 3.2%.
- The highest productivity was noted in the following countries: South Korea (+6.4%), Chile (+5.3%), Estonia (+4.6%) and Ireland (+4.5%).
- Additionally, to analyse the progress in proportion in workers' productivity, on the other hand, we look at the strong effect of the real productivity standard or the GDP output per hour worked. Chile, Mexico, and the Russian Federation had the least productivity in 2011, making profits of $20.40, $20.40, and $22.1 per hour worked, respectively.
- At the other side of the curve, Luxembourg, Norway, and Ireland had the highest effective labour in 2010, producing outputs of $77.10, $74.90, and $66, respectively, per labour hour. The USA was ranked fourth, with an output of $60.90 per unit hour of labour.
- Luxembourg is a good example of the significance of assessing both productivity progress and real productivity in assessing the efficiency of a specific workers' market. Even though it reduced in productivity gain or progress from 2008 to 2011, it is ranked as the highest of the OECD nations in the area of productivity.
- Australia was the top performer and the only country to merit an "A".
- Canada achieved a "B" grade for labour productivity growth, placing fifth among the 16 countries.
- Six countries suffered declines in output per hour worked in 2012 – a reflection of the severity of economic conditions across much of Europe.

Figure 2.9 The Organization for Economic Cooperation and Development (OECD) labour productivity growth, 2012 (per cent)



Source: OECD 2012

2.25 CRITICAL SUCCESS FACTORS FROM THE RESEARCH FINDING AND ITS CORRELATION WITH OTHER COUNTRIES

Many researchers carried out numbers of studies about the productivity problems in different countries, these countries either developed or developing have ranked different critical success factors (CSF). The outcome or the conclusions of their investigations and the literature survey in this thesis about the CSF are ranked and listed in the following table 2.13

Table 2.13 shows that lack of material is the number one critical factor within productivity problem in some countries, but not in Australia, as a developed country, because it has no significance on productivity. In advanced nations such as the USA, there is less difficulty with supervisor skills than in growing nations. At the same time, both types of nations experience the effects of rework to the same degree. Advanced nations can experience considerable problems from absenteeism of the workplace.
In addition to the previous explanations, when concentrating on advanced nations, the conclusions of the research, as shown in Tables 2.13 and 2.14 were rated on a number gauge and so, unfortunately, a deep investigation could not be used (Kaming PF et al. 1997b), although Australia was ranked on a RII basis. Accordingly, this could be the

reason why the productivity difficulties in Australia seem to vary from those of other advanced nations. Nevertheless, if the results are compared with three other advanced nations, it can be noted that Thailand, Iran, and Nigeria have in common a similarity in their building rate difficulties. In Thailand and Iran, most of the common aspects are rated the same and are identical. The best three aspects and the worst three aspects in Nigeria and Thailand are also identical but are varied in their ratings.

There are a number of factors. These factors can be classified as primary factors and secondary factors. Primary factors have a direct effect on productivity and would normally have a RII of 0.5 or greater. Secondary factors are normally linked to primary factors. For example, in this research, incomplete drawings have been found to be a significant primary factor directly affecting productivity. This factor has a number of secondary factors that contribute to it. Such factors have been found to include designers providing insufficient detail, inadequate examination of an approved drawing, and an incomplete site surveys Primary and secondary factors that affect construction productivity are further discussed in sections 4.2.10 to 4.2.13.

Table 2.13 International ranking of critical success factors in construction industry

Factors affecting the construction productivity	RANKING									
	USA *	U.K. *	Nigeria *	Iran *	Thailand **	Indonesia *	Malaysia	Kuwait***	Uganda	
Lack of material	1	1	1	1	1	1	6			
Lack of tools & equipment	2	5	2	3	5	4	8		4	
Rework	3	2	4	2	10	10	10	1	3	
Worker turnover	4	4	3	5	16	6	5			
Intervention	5	3	5	6	2	5	20			
Supervisor delay (training session)	6	6	n/a	4	4	4	8			
Poor communication					6	6	9			

Incompetent supervisor					3	3	3	3	1	
Absenteeism						5		11		
Poor Site layout					8	8		6		
Site overcrowding					21	7		8		
Incomplete drawing					2	2		7	5	
Work overload					17	11		10		
Inspection delay					9	9				
Accident/Safety					18	18				
A poor site condition						19				

Source: Adapted from (Kaming et al. 1997) *; (Alwi 2003)* ; (Makusawatudon 2004)**; (Jarkas & Bitar 2012)***, (Thomas & Sudhakumar 2014)

Table 2.14 Ranking of the most severe factors with other countries.

Factors affecting the productivity	RANKS								
	Indonesia *	Nigeria*	UK *	USA *	Australia **	Chile***	Gaza Strip	Deep south USA	
Lack of material	1	1	1	1	4	1	1	5	
Lack of tools and equipment	5	3	5	2	13	2	3		
Intervention	3	6	2	5	n/a		4	2	
Absenteeism	4	5	6	6	11	4	3		
Superintendent delay, Training session	6	4	4	4	n/a		2	1	
Rework	2	2	3	3	1	3	1		

Adapted from (Kaming et al. 1997); (Alwi 2003)* **; (**Thomas & Sudhakumar 2014); (Makusawatudon 2004)**; (Rivas et al. 2011)**

2.26 IDENTIFICATION OF GAPS IN THE LITERATURE

The study recognised a few overlapping issues leading researchers to gaps in the literature. The processes used to develop the research questions for this study from existing research are outlined in Table 2.15. Gaps found in the research are not to be interpreted as detracting or disagreement of the original literature content – rather they should be interpreted as an avenue to expand on the existing content by creating further research questions. Gap identification is widely encouraged by academics to broaden the horizon of researched topics. Table 2.15 outlines the three basic processes used for the identification of gaps in the literature (repetition spotting, oversight spotting and administrative spotting), which in turn resulted in the formulation of the research questions for this study (refer to Section 1.5). The processes used are based on a paper on ways of constructing research questions by Sandberg and Alvesson (2011). They are discussed in more detail in Section 7.5.

Table 2.15 Identification of gaps in the literature

Essential way of gaps	Exact pattern of Essential way of gaps	Investigated Journal item
First Repetition spotting	Challenging Explanations	Megha & Rajiv 2013; Arslan & Kivrak 2008; Navon 2005; Enshassi et al.2014; Baker, Murphy & Fisher 1988; Morris & Hough 1987; Pinto & Slevin 1987; Turner & Muller 2003; Baker, Murphy & Fisher 1988; Cleland & King 1983; Pinto & Kharbanda 1995; Pinto & Slevin 1987; Tukel & Rom 1995; Walid & Oya 1996; Tran & Tookey 2011; Tran & Tookey 2011; Cox & Hampson 1998
Second Oversight spotting	i- Unnoticed Area	Chancellor 2015; Assaf & Al-Hajji 2006; Bettaineh 2002; Al-Momani 2000; Baldwin & Manthel 1971; Chan & Kumaraswamy 2002; Frimpong, Oluwoye & Crawford 2003; Kaming et al. 1997a; Odeh, Odeyinka & Yusuf 1997; Ogunlana & Prumkuntong 1996; Holt & Gary 2014; Baker, Murphy & Fisher 1988; Cleland & King 1983; Locke 1984;

	ii- Under investigation	Parham 2005; Holt & Gary 2014); (McCabe, O'Grady & Walker 2002); Banik 2001; Love 2002b; Chancellor 2015; Jiukun, Goodrum & Maloney 2007.
	iii–Shortage of practical support	Bandow & Summer 2001; Hendrickson 1998; Bhattacharjee et al. 2011; Bandow & Summer 2001; Hartman 2000; Kaming et al. 1998; Dingsdag, Sheahan & Biggs 2006; Ruppert 2011; Holt 2014; Arditi & Mochtar 2000; Malisiovas, 2014.
Third Administrative spotting	Reaching and integrating current literature	Enshassi et al. 2014, Hughes & Murdoch 2001; Bhattacharjee, Ghosh & Young-Corbett 2011; Cox & Hampson 1998; Flanagan & Norman 1993; Adrian 2002; Sveikauskas et al. 2014).

Source: Adapted from Sandberg and Alvesson (2011)

2.27 CONCLUSION

The literature survey for the critical success factors was used to establish a complete list of these factors. In a previous study by Assaf and Al-Hejji (2004), around seventy-three factors were listed and were allocated into nine groups as follows: factors related to projects, proprietor related factors, contractors, consultant related factors, factors relating to construction material, design, equipment, labours and other external factors. Some of these factors listed by Assaf and Al-Hejji (2004) were neither common nor applicable due to studies and discussions with engineers, project managers, and proprietors. However, they could have some insignificant impacts on the scheduled project timeframe.

In another study by Odeh and Bettaineh (2002), some of the twenty-eight critical success factors in the construction industry were identified and grouped in eight major groups such as consultants, labours, material, equipment, contract, and some external factors. Odeh and Bettaineh (2002) evaluated these factors and assessed the relative importance index for them. Other researchers for example: Shamas-Ur-Rehman and Stephen (2008) ;Nguyen et al. (2004) support these findings.

The conclusion of the previous studies for the critical productivity success factors (CPSFs) were identified as:

1) Well organized, a united working group to manage, plan, erect and produce the work.
2) A series of contractors that allow and encourage different consultants to work as a group in harmony with united aims and goals.
3) Strong background in administration and authority, outlining, architecture, structure, and operation of comparable facilities.
4) Appropriate, costly optimization of the data from the proprietor, stakeholder, architect, contracting firm, and engineer in the outlining and design phase of the project (Mengesha 2004).

In this chapter, many aspects were covered such as productivity definition, construction industry interpretation, significant influences of the construction industry on the labour market, construction project parties, Australian construction industry performance, supervisor performance, risk management in the building and construction industry and international labour productivity (a brief look from the Organization for Economic Cooperation and Development OECD 2012).

Chapter 3, which focuses on research methodology and questionnaire design, discusses the questionnaire survey used in this study to collect the important and necessary data about the critical success factors for a group of project managers for analysis and results. .

CHAPTER 3

RESEARCH METHODOLOGY AND QUESTIONNAIRE DESIGN

3.1 INTRODUCTION

This section of the thesis examines contemporary study approaches with the aim of determining the best and most suitable methodology for the present research project, including this study plan of action and confirmation of the methodology, the approach applied and the model choice in this investigation. The selected procedures:

- Need a methodology to examine changes and a graduated system to analyse the occurrences.
- Apply statistical analysis for individual understanding using the Statistical Package for the Social Science (SPSS); and
- Investigate to discover the data during the scientific study for motivation and ramifications.

Study into construction productivity has applied both measurable and subjective means. The measurable approach involves work on study-based replicas, determinant replicas (Thomas et al. 1990) and statistical flow examinations of inputs such as workers' costs, building component prices and real estate financial values (such as Tran & Tookey 2011). For instance, research using subjective means has involved investigation inside forces on workers' productivity (Durdyev & Mbachu 2011) and the study of the projects that influence construction productivity (Lim & Alum 1995; Makulsawatudom, Emsley & Sinthawanarong 2004). This study uses a similar subjective means.

The study assumes that the measurable methodology is the most suitable based on the study's needs. The measurable methodology again coordinate with the principle that most of the investigations attempted in construction management, architectural, and real estate businesses are involved in the quantitative methodologies. This study investigates in real time the main aspect influencing the productivity of the construction industry in Australia, and includes research methodology and sampling techniques used to classify the greatest influences on productivity in the construction industry in Australia. This study is an in-depth type of research investigating project managers' attitudes towards and perceptions of productivity problems and improvement programs.

In the literature reviews and preceding investigation has been ascertained the use of dissimilar guidance and methodologies for achieving the needed targets, aims, and intention. The former research concentrated on some aspects, for example:

- factors influencing the productivity of construction projects
- using different guidance such as expenses, time, or feature of achievement
- measurement of construction productivity
- different aspects related to productivity improvement.

The current study aims, as stated above, require various methodologies. The predominant methodologies acquired from the literature analysis are the sampling questionnaire survey and the Delphi expert's technique.

This chapter presents the stages which were carried out to accomplish the research objectives. These stages cover the following steps:

Research objectives: the objective of the investigation detailed in this thesis is to confirm the perceptions, from the project manager's aspect, of the components influencing construction productivity in Australia.

Literature survey: a literature survey assesses information from research on the topic of construction productivity. The review describes, summarises, evaluates, and clarifies this information. It gives a hypothetical base for the study and helps to decide the disposition of the study. It selects a small numbers of projects that are essential to construction productivity, rather than attempting to gather a great number of projects that are not related to the research subject matter. A literature survey is deeply involved in searching for knowledge and incorporates the description and articulation of the connections between the literature and the area of the study. The articulation of the connections between the literature and the area of the study. The pattern of the literature survey may change with types of studies.

Questionnaire design: the investigation was managed by a methodical survey that was distributed to a number of selected construction project managers in Australia.

This questionnaire sought circumstances and facts about the clients, scoring on a zero to four Likert scale by each of them with regard to the significance of a number of main factors likely to influence construction productivity. The projects that were scored were then arranged utilising a relative importance index (RII).

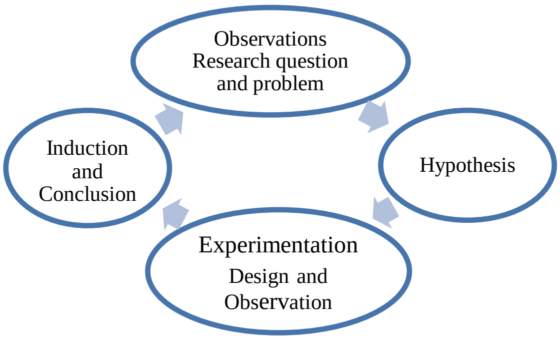
Results analysis: the study assesses the RII of a number of initial aspects that have a relatively crucial impact on construction productivity.

3.2 RESEARCH STRATEGY

The definition of 'research' points to the improvement of a modern piece of knowledge. Scientific research refers to the precise, reserved, exact, experimental, and critical research of a hypothetical proposition concerning a trust connection to get the right solution to any difficulties or to define new information (McCuen 1996). Characterizes scientific research as the study of development through exercising regularly with the means of science. Scientific study and the authentication of acceptance around actual world development include experimental study built on the opinion that all information begins in experience (Stone 1978).

The study bestowed in this research compromise with certainty so the goals and built on this practical study is the methods applied in this research. The practical scientific investigation cycle (Mc Cuen 1996; Stone 1978) in the following diagram demonstrates the actions for the practical research of an aspect (Figures 3.1 ; 3.2).

Figure 3.1   Empirical scientific research cycle



Source : (Mc Cuen 1996; Stone 1978)

Observations: examination of a current aspect leading to an obstacle report and the study investigation.

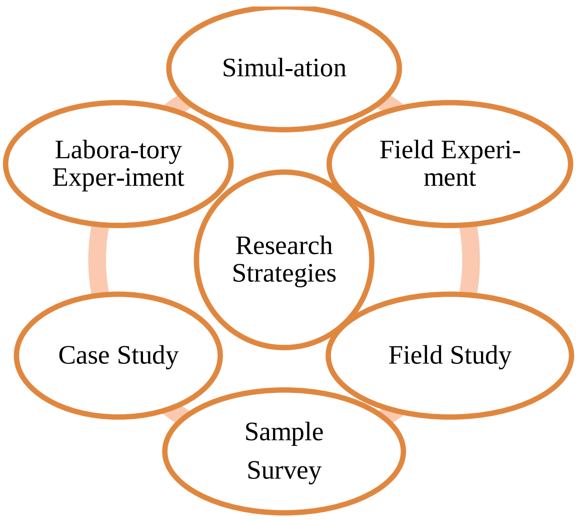
Hypothesis: a precise explanation of accurate connections, which supply a clarification of and resolution to the obstacle.

Experimentation Design and Observation: the planning of the investigation, through an efficient trying out of the theory.

Induction and Conclusion: an observation of the preliminary conclusion in a precise assertion of the approach.

Practical studies have various approaches to the study procedure. An illustration of practical approaches is given in Figure 3.2.

Figure 3.2   Empirical research strategies



Source : (Mc Cuen 1996 ; Stone 1978)

Yin (2003) points out that the following hierarchy does not distinguish a research strategy.

- Special research is applicable for the descriptive stage of an examination.
- Surveys are suitable for the explanatory stage.
- Investigations are the appropriate method of advancing descriptive analysis.

However, by conditions, for example:

- the kind of study investigation question posed
- the range of control that an examiners has over actual behavioural events
- the degree of focus on existing as opposed to historical events.

The inquiries for this thesis are:

- Investigating the important factors for project productivity delay in the construction industry in Australia.
- Studying the relationship between the delay factors and the critical success factors within the construction industry in Australia.

These study inquiries and the changes included in the study help to distinguish between the different approaches available to the investigators. Table 3.1 shows the conditions for various research strategies.

Previous studies were dealing with earlier events or new occurrences. Former studies can provide some help in finding a solution for a complicated issue through an investigation of the past (Bennet 1991). This special condition examines the new circumstances, particularly when the consistent nature of the aspect being studied cannot be manoeuvred. Other former studies, special studies, or case studies are in possession of two points of confirmation: honest consideration or an examination and organised questioning and evaluations.

Table 3.1: Relevant situations for different research strategies (Yin 2003)

Strategy	Form of research question	Requires control over behavioural events	Focuses on contemporary events
Experiment	How, why	Yes	Yes

Survey	Who, what, where, How many, how much	No	Yes
Archival analysis (e.g. Economic study)	Who, what, where, how many, how much	No	Yes/No
History	How, why	No	No
Case study	How, why	No	Yes

The special case was determined to be the most suitable methodology to answer the study inquiry classified in Chapter 1. This is because of its capability to use several types of evidence, for example, artefacts, research, written communications, and interviews. To administer the study, the data compilation means chosen in this investigation labelled the factors and analysed the interaction of the causes and the delays. Lastly, the consensus Delphi approach was chosen to confirm the major critical success factors in the Australian construction industry to enhance the industry achievements.

3.3 THE SURVEY STRATEGY

A survey is a popular way to collect specific knowledge about specific projects; surveys gather feedback from major sources, for example, project managers, customers and agents, and assist to create consensual resolutions (Naoum 2016; Mc Killip 1986). The survey approach includes investigation where:

- The investigation relates to a recognised community. A pilot survey assists the investigator to make assumptions about the research conclusion.
- Information is drawn precisely from clients utilising an efficient method, for example, an inquiry survey or personal consultation.
- Examiners manipulates no independent variables
- The rules is that whatever information is collected is normal
- The responses are considered to be broadly unaffected by the circumstances in the way they are drawn out.
- The effects of confounding variable are regulated analytically.
- The goals of the study range from examination of experience to theory verifications.

Surveys are usually piloted to a few clients to validate whether the inquiry or the questionnaire is simple to comprehend, suitable to the study subject matter and clear (Fellows & Fong 2003), and to understand more about the timeframe in which to conduct and to manage the inquiry or questionnaire. On the other hand, some advice and opinions relating to particular issues might be important to the research but may be missed. In addition, piloting will indicate to the investigator that the study is weighing the correct idea, and therefore its lawfulness and accuracy.

3.3.1 ADVANTAGES

- The sample is chosen to permit generalisation to a known group.
- The outcome of the analysis is precise due to a high number of participants and normally low percentage error.
- Arbitrary test processes decrease or remove obstacles of unfairness.
- Information compilation is done in normal frameworks.
- Information is collected straight from clients.
- The examinations frequently harvest information that suggests new theory.
- The inquiry survey will be cheaper if using Australia Post to collect the required information compared to the cost of direct interview information.
- A survey of orderly information accumulation methods (for example, conference, census, and consideration) shows the items can be applied separately or together.

3.3.2 DISADVANTAGES

- The survey's clients partially or collectively can refuse participation in answering the questionnaire survey because of their concern and fears.
- The majority of questionnaires are one-go trials; therefore, the information gathered to check random relations between variations is minimal.
- From the cost viewpoint, the questionnaire survey for an investigation study usually costs too much money because of the number of the people involved in administering and managing the survey.
- The patterned reply arrangement of many sample survey measures (e.g. questionnaires and methodical interviews) may force respondents to subscribe to statements they do not completely authorise.

- Sometimes the responses from the participants in a questionnaire survey are far less than expected, therefore the survey should be sent in bulk.

There are two kinds of inquiry (excluding face-to-face communication and interviews) involved in the information solicitation tool in the studies done by Ashley & Bonner 1987; Muhwezi, Acai and Otim (2014); and Assaf and Al-Hejji 2006. The main groups surveyed either were connected to a targeted project (as in the study by Ashley & Bonner 1987) or had the practical skills on a construction site (as in the study by Assaf & Al-Hejji 2006). This research will apply these two methods in gathering information. The two kinds of survey are as follows: the first survey was initiated to solicit the information needed from expert project managers with the Delphi technique. The second survey was an ordinary survey to solicit data about some individuals' backgrounds for project managers and normal projects.

The first survey obtained recollections of site experiences and skills from the project engineers who had worked on construction projects in Australia completed within the last ten years. The respondents to the survey were project managers (PMs).

The other survey gathered assumptions in a style very similar to the first survey; the main groups were engineers who had been involved in the Australian construction industry for not less than a decade and stakeholders with a background in building construction projects.

3.4 CONSENSUS-FORMING TECHNIQUES

The method used in this study implemented the consensus-forming model. This portion of the study concisely outlines the various consensus-forming models and presents the hypothesis for the introduction of the Delphi method.

The beliefs of specialists are required in an abundant field in which fair information is non-existent and abstract acumen plays an important part. Consultants or experts in the construction industry usually hold many different opinions, and it was worthwhile to get them involved in the questionnaire survey. The idea of consensus-forming is built on the consideration that the assessment of a team of experienced project managers will be more reliable than the beliefs of personal experts, adjusting for personal partiality and misreport. A team of clients for the survey can be selected through different channels; only three of them are debated in this part of the thesis:

- collaborative team procedures
- theoretical team procedures
- the Delphi procedures method.

3.4.1 INTERACTING GROUP PROCESS

The communications procedures to commission decision-making is identified as a team conference as the entire conversation action appear among representatives with less authority or orderly grouping. The procedures of decision-making in the communication team are:

- Unorganised team communications to collect and gather the opinions of members.
- Most casting their votes on preference by manual add (Delbecq 1968).

3.4.2 THEORETICAL TEAM PROCEDURES

Initially advanced as an administrative preparation method by Delbecq, Van de Ven and Gustafson (1975), the nominal group technique (NGT) is a consensus-planning form because it relies on preference factors (Delbecq 1968). In NGT, colleagues form one group for a consultation managed by a mitigator. NGT has been introduced as different to the focal point team and the Delphi method. It demonstrates a different arrangement than the focal point team; it takes benefit of the linked results constructed by team of members. NGT is theoretically a team process, as the hierarchy is supported on an exclusive base. NGT includes procedures very much similar to the Delphi technique Dalkey (1969) alongside the goal of being the investigation of ideas for conclusion from a group of expertise (Adler & Ziglo 1996). The main dissimilarity between NGT and the Delphi method is that conversation comes between clients through NGT methods. Furthermore, NGT sub-divides the procedures of autonomous idea production, methodical response, appraisal, and collection of ideas. It depends on personal cooperation. A study by Gustafson demonstrates that NGT exceeds Delphi in the following:

- Voting is unknown
- Equal opportunity between the team affiliates
- Interruptions (conversation noise) inherent in another team method are the lowest.

NGT is a methodical team information-gathering exercise where everyone works in partnership with one another and stays silent for some time. NGT pursues a guiding series of analytical steps (Delbecq & Van de Van 1971), i.e.

- Quiet creation of concepts in handwritten.
- Steady periodic form of performance and documentation of autonomous opinions on a whiteboard or flipchart.
- Analysis of opinion and free calcifications of preferences.

Sometimes applying directly facing discussions could create complications as a result of:

- A superior representative of the team could espouse ideas in a way contradictory to the demonstrated data.
- Public discussion might compel participants to switch ideas openly.

3.5 RESEARCH FRAMEWORK FOR CONSTRUCTION PRODUCTIVITY

This research sub-divided into four essential parts. The first part introduces the research objectives and describes the methodology implemented to carry out the research. Part two displays an overview of the literature relating to the critical success factors that influence the construction productivity in Australia. Part three presents the statistical data collection and analyses stage. Describes the construction and development of the questionnaire survey and Delphi survey and testing both surveys and get the results tabulated. Finally, part four drawn the research conclusions and writing recommendations for future research.

Research framework for construction productivity

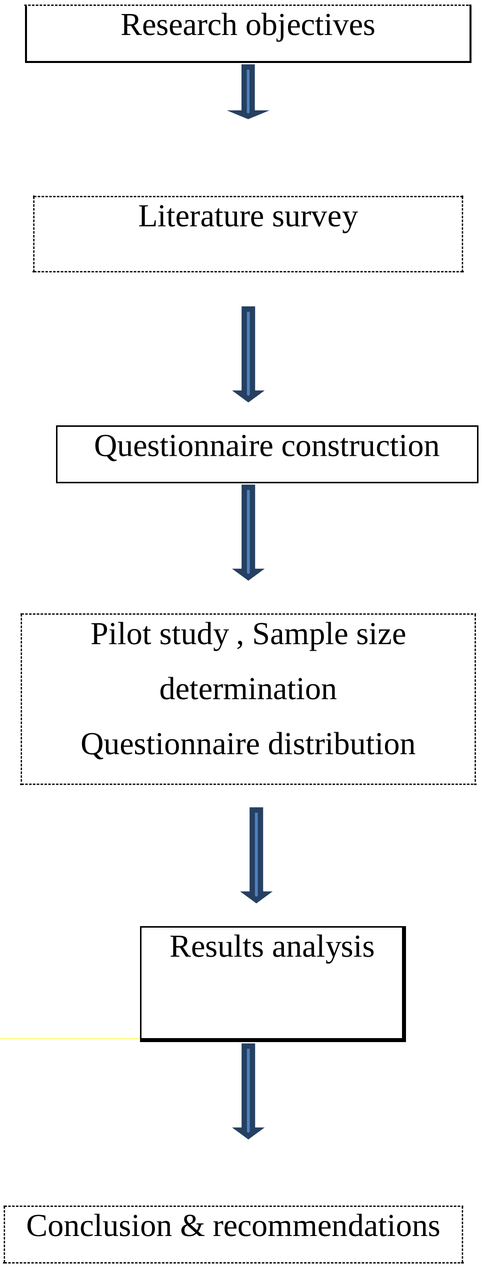


Figure 3.3: Research framework for construction productivity

3.6 THE METHODOLOGY FOR THIS RESEARCH

Examination of construction productivity has applied two approaches, the quantitative (the measurable) and the qualitative (the subjective). Quantitative or measurable approaches include work-study base style, project imitation (Megha & Rajiv 2013; Thomas et al. 1990) and mathematical flow investigation of information such as workers' expenses, building component costs and real estate prices (for example, Tran & Tookey 2011). Examples of studies employing qualitative or subjective approaches include investigating the constraints on workers' productivity Durdyev and Mbachu (2011) and researching the projects that disturb construction productivity (Lim & Alum 1995; Makulsawatudom, Emsley, & Sinthawanarong 2004). The study in this thesis applies similar qualitative and quantitative methods.

This study discusses the aspects hindering productivity in the construction industry in Australia. The theory of the procedures, what is thought to carry out the main goals of this study, is discussed below:

3.6.1 **OBJECTIVE ONE** (To pinpoint the hindering aspects that presently continue in the construction/ building business in Australia by uncovering the best practices prevailing and the complications influencing productivity achievement.)

For improving productivity in the construction industry, an investigation of the aspects influencing it, either positively or adversely, is important. Gaining the benefit of the indicated aspects that positively alter construction productivity, and remove (or regulating) aspects which have an adverse influence will significantly enhance construction productivity. If all the affecting aspects are successfully traced, it will be easy to predicting the position of the productivity (Muhwezi, Acai & Otim 2014; Lema 1995). A number of investigators have studied the aspects that significantly affect construction workers' productivity (Megha & Rajiv 2013; Heizer & Render 1996; Kaming et al. 1998; Lim & Alum 1995; Olomolaiye et al. 1996; Olomolaiye, Jayewardene & Harris 1998; Rojas & Aramvareekul 2003 b; Teicholz, Goodrum & Haas 2001; Thomas et al. 1991; Sanders & Thomas 1991; Wachira 1999).

The aspects affecting construction labour productivity have been the subject of inquiry by many examiners (Muhwezi, Acai & Otim 2014; Kaming et al. 1998; Olomolaiye, Jayewardene & Harris 1998; Rojas & Aramvareekul 2003 b; Teicholz 2001). So far, although there have been many studies, investigators are not yet capable of deciding on a worldwide group of aspects that essentially affect productivity; in addition, there is no agreement on the categorisation of all these aspects. Many means have been used to make connections in the categorisation of all these aspects influencing construction productivity. A United Nations economics report (Parham 2005) stated that, in ordinary conditions, two significant groups of aspects influence project workers' productivity: bureaucratic progression, and project progression. Bureaucratic progression surrounds environmental elements of work, qualifications needed, architecture analysis, etc. Project progression is connected to the work surroundings, and whether a job is productive and administered. Administration factors contain climate, building components and machinery, overpopulation with blockage of work sites, and irregularity of work sites.

3.6.2 **OBJECTIVE TWO** (To decide the most compelling key barometer of building/ construction productivity in Australia).

A methodical sense analysis approach was used to examine the effects of some aspects hindering building productivity. In addition, the senses assisted in studying the perceptions of the project managers on the aspects that influence achievement in the construction industry, for example, rework, work overload, absence of materials, completeness of drawings, communication, absenteeism, and deficiency of apparatus and machinery. The following theory of the relative importance index (RII) is applied to decide project managers' approach to the relative importance of basic achievement sign in Australia's construction works. The RII is figured out as follows (Callistus1 et al. 2014).

$$RII = \frac{\sum \mathrm{W}}{(\mathrm{A \ x \ N})}$$

Where:

W = measurement likely to every aspect by participants varying between 4 heights and 0 for nil answer as follows (4, 3, 2, 1, 0)

A = highest measurement = 4

N = the entire number of the participants

3.6.3 **OBJECTIVE THREE** (To classify the negative achievement aspects, which are most significant in hindering productivity success).

The RII method is still in force to decide the most important element's accomplishment

sign of the structure and output/work rate. The RII is calculated as
indicated previously.

3.6.4 OBJECTIVE FOUR (To analyse, using a unanimity expert group, the greatest critical success aspect of the Australian building industry and to evaluate the degree of agreement/disagreement among project managers (using Delphi techniques) regarding the ranking of the relative importance index (RII).

The degree of concurrence among project managers concerning the ratings of aspects was decided in agreement with the Kendall Coefficient of Agreement. The degree of concurrence could be decided by the following formula (Frimpong, Oluwoye & Crawford 2003; Moore et al. 2003):

$$W = [12\ U - 3\ m^2\ n\ (n-1)^2\ ] / [m^2\ n\ (n-1)]$$

Where:

$U = \sum^{n}_{j=1} \{ \sum R\}^2$

n = number of factors

m = number of groups

j = factors 1, 2, 3… n.

3.6.5 OBJECTIVE FIVE (To identify the cooperation among the ratings of consultant owners and contractor groups for RII).

To examine the theory that there is no great dissimilarity of belief among the project managers concerning construction productivity aspects, Kendall's Coefficient of Agreement was in addition applied in accordance with two theories (Megha & Rajiv 2013; Frimpong, Oluwoye & Crawford 2003; Moore et al. 2003):

Valueless theory H0: There is an insignificant rate of concurrence among the project managers.

Another theory H1: There is a high rate of concurrence among the project managers.

3.7 QUESTIONNAIRE DESIGN

The questionnaire survey was realised by an investigation example made up of 16 questions and inquiries. These inquiries were assigned to skilled architects, for example, projects managers, site engineers, and office and organization managers/ administrators who had great experience in the building industry. Their ample experience was appropriate for both the pilot survey and the main questionnaire.
The questionnaires consisted of four major sections:

- a written communication giving the aims and the concept of the questionnaire
- an analysis of the research
- an explanation of the pilot survey
- the main inquiry/questionnaire itself.

The entire answers were evaluated by applying the SPSS program. The named aspects were rated by applying a relative importance index (RII) calculated from examining the information collected. The conclusion of the information formed the basis of further research into the influence and seriousness of the essential aspects considered to have a reasonable influence on construction productivity in Australia. These particular aspects were classified within basic factors and subordinate aspects according to the basic aspects recognised from the research, as follows:

- basic aspects influencing development of work rate (22 aspects)
- aspects contributing to three of the basic aspects (subordinate aspects):
  - ➢ aspects related to inadequate drawings (7 aspects)
  - ➢ aspects related to the shortage of building components (10 aspects)
  - ➢ aspects related the shortage of tools and the equipment (8 aspects)

The survey contained some circumstantial data about the individuals and their institutions (11 compressed answers), an extra comprehensive inquiry requesting them to rank the basic aspects influencing building work ratings on a 0 to 4 Likert range, and one inquiry of each of the three groups of the subordinate aspects demanding a rating, on a 0 to 4 Likert scale, of the addition of these aspects to their specific basic aspects. The last inquiry was an arbitrary inquiry that asked the participants to contribute any additional significant data.

3.7.1 CHOOSING THE PROJECT MANAGERS (PMs)

Many companies and institutions enforce secrecy of information regarding their project managers; therefore, it was very time consuming to collect particulars about a large number of the chosen project managers, 89 competent project managers chosen through very efficient project manager institutions and a construction businesses organization, who participated. The main inquiry survey received 36 completed questionnaires, characterising a 40.4 % incoming rate.

Hamburg (1970) has supplied a rule for computing the lowest numbers of an example to evaluate a dot rate in a considerable group of people. This number is an action of the assurance break (that calculated by the total of accepted alteration from the mean), the difference in the group of people and the wanted limit of mistake of the estimation, as follows:

$$n = [z^2 \text{ X } \sigma^2] / [e^2]$$

Where:

n = sample size

z = number of standard deviations from the mean

σ^2 = population variance, and

e = margin of error.

Klir and Folger (1988), supplies a similar rule that he mentions can be used to reckon principles on a Likert range. If the group of people is limitless and the z rate is steady at 2, this rules is very much like the one of Hamburg (1970). Implementing this rule, applying a population deviation of 0.9 (near the real outcome for the total of 15 basic aspects influencing building work rate, if the Likert range rate is obvious digits) causes conclusions in a predicted dot error for a likely Likert range rate of +/– 0.20 between two accepted alterations from the predicted rate of an example of 89 project managers canvassed, and +/–0.32 for the 36 project managers' replies. It is likely that a Likert range is based on inner experience rather than facts, so it could be disputed that a rate of +/– 0.32 is not expected to include the ranking of a specific aspect from its ranking in a larger group of people where the example is picked up. As a test for reckoning the capacity of a perfect example for a questionnaire, research of building work rates by Megha and Rajiv, 2013; Kaming et al. 1998 ; and Makulsawatudom, Emsley and Sinthawanarong 2004; applied 31 and 34 project manager replies in sequence.

3.7.2 PRIMARY TESTING OF SURVEY

A primary testing of the survey was conducted with a trial example that contained 16 questions. This survey was delivered to a group of experienced architects, for example, project executives, site managers, academics, project administration officers and construction executives. They had significant backgrounds and professional expertise in the building industry. The pilot survey (primary testing survey) covered the following: required data, data collection, population, and samples (Fayek, Dissanayake & Campero 2003).

This primary testing survey was carried out at the beginning of the research for verifying the character and capabilities of the formal inquiry before distributing that to the respondents. The primary testing survey was designed to obtain responses which would assist the investigator to enhance the technique of response accumulation from the participants and gauge the precise time needed to answer the entire inquiry, and to recognise any other difficult matters with the questionnaire pattern. The responses collected from the primary testing survey were applied to advance the main survey. A slight alteration was carried out to the main questionnaire and its formatting because of the primary testing survey (Li et al. 2005).

The subsequent components were a conclusion of the essential analysis received from the primary testing survey:

- The survey may start with a top letter.
- The survey may contain a ‘study at a glance’ sheet to give respondents some background about the study and its purpose.
- The questionnaire should contain a consent form to be signed by respondents and some general information about their organizations and their contact information.

- A few aspects and terms needed to be changed or presented with extra detail.
- A few aspects were duplicated once and twice carrying the same content, therefore must be eliminated.
- A few aspects and terms must be rephrased to give extra comprehension.
- A few aspects must be combined, as urged by regional experienced project managers.
- Some parts of the questionnaire needed to be combined together with shortening the questionnaire
- A few aspects must be reconstructed to give a more appropriate and logical signification.
- A few of the inquiries that were neither effective nor significant from the construction work rate viewpoint were eliminated or enhanced.
- Some choices should be added in some questions to create a precise and appropriate selection for individuals.
- The questionnaire should be partitioned into the following:

  - ➢ The start section deals with demographic data about the participants
  - ➢ The middle section has an introductory question about construction productivity
  - ➢ The third part deals with the main factors, which have a reasonable to extreme impact on building work rate in Australia.
- Some tables were either too long or crowded with factors and data, which should be combined or shortened.

These results were utilised in developing the final questionnaire, which was sent out to 89 project managers.

3.8 QUESTIONNAIRE INVESTIGATION

This investigation was attempted in two phases as follows:
Starting with phase number one: the collection of data, which included reviewing related literature and collecting information during the working location visits for pilot questionnaire conversations with different ranks of project managers.

The second phase focused on data examination of the information collected within the inquiry survey to identify the most relevant factors causing productivity problems; this guided the structure of the survey (see Appendix C) that was handed out to a number of project managers in different projects with different capacities.

The questionnaire carried both the instructions and questions to the participants and provided space for the participants to write any comments. There were some considerations for both the subject content and the wording of each question in terms of shared vocabulary and clarity. Each question was stated in such a way as to be as precise, short, simple and understandable as possible.

As mentioned, there were three essential sections of the survey. The first part was an introduction in order to clarify the concept and the aim of the questionnaire (the cover letter and the study at a glance, see Appendices A & B). The second part, which was the main questionnaire, included questions 1 to 16, as follows.

Questions 1 to 10 were background information seeking data about the respondents, their work, and their organization. Questions 11 to 16 comprised the main part of the survey. The respondents' gender was mainly male because the construction industry has traditionally been male-dominated, although during the past two or three decades women have begun to be involved in many different aspects of the construction industry and they are achieving at a very high level.

Question 2: asked the age of the project manager.

Question 3: addressed their qualifications. The construction industry has a couple of main methods to step up the ladder for promotion to project manager. The first is to work as an engineer (site engineer, project engineer, assistant or deputy project manager and so on) until the necessary experience is gained. The second is to obtain a qualification from a vocational college such as a TAFE or a tertiary degree from a university such as the University of Southern Queensland (USQ) or Queensland University of Technology (QUT) in project management or construction management.

Question 4: addressed the issue of employment and experience in different areas of the construction industry such as residential, commercial, industrial, civil and infrastructure, and the area's general influence on construction productivity.

Question 5: asked the experience of the project managers in their current organization. In the construction industry, it is well known that it takes approximately 20 years of experience for a civil or construction expert to get the necessary experience required to be a good project manager.

Questions 6 and 7: specified the project manager's length of tenure with their current employers, the number of project managers who have resigned and why; this data reflects the issues of loyalty and commitment to their employers and their organizations, and whether their stability on the job greatly affects productivity.

Questions 8 and 9 covered the types of contractors and the nature of the work performed by their organizations, in order to include all types of construction work and the corresponding levels of productivity.

Question 10 asked project managers to provide their opinions about their employers, subordinates (efficiency, friendliness, teamwork, communication, meeting deadlines), working environment and level of payment, as these factors have a direct relationship with construction productivity.

Question 11 addressed the main factors that have been shown to cause a negative impact on the building work rate and asked respondents to rate the significance of these various issues, such as shortage of building components, which has a great impact on the construction productivity. It is definitely plausible, because building components are essential for building works (Enshassi et al. 2014 and Jarkas and Bitar (2012). As there is no material for the construction workers to continue their work with, this will cause a significant lack of productivity. Furthermore, these employees and trades will maintain being paid their wages regardless of the work being finished or not thus causing wage budget fluctuation. Lack of materials on site will also cause a serious delay in the sequence of the work plan and delivery of the project on time. Further, because the project actions are normally interconnected, if there is a material shortage for a specific project, this will affect other projects and scheduled actions.

To investigate the matters behind all these aspects, the participant project managers were requested to list the normal reasons for lack of materials, based on their comprehensive experience in the construction industry (Fayek, Dissanayake & Campero 2003).

Question 12 considered the issues of materials shortages and insufficiency of funds, which is a very important factor in materials shortages. There is no doubt that this factor, combined with other factors such as mishandling, misuse, improper storage methods on the site, improper material delivery to the site and on-site trafficking, causes productivity problems.

Question 13 – Incompleteness of drawings is the largest detracting project influencing building working rate. Once inadequate drawings are hindering a project from progressing because of, say, interruption for correction or interpretation of drawings and specs, for sure this aspect affects productivity.

Question 14 – Rework is another of the most critical factors affecting construction productivity because rework incurs time and expense. The factors causing rework can be associated mainly with worker competence, skills of tradespeople and project managers' knowledge, and skills. Insufficient skills or backgrounds in design are part of unskilled tradespeople and workers, although inexperience, caused by inadequate guidance, typifies incompetent supervisors, project engineers and project managers. Other causes of rework are changed orders and incomplete drawings.

Question 15 covered extra factors affecting construction productivity. These were listed according to their critical effect, such as shortage of funds for procurement, planning, number of sites under construction at the same time, condition of broken tools/equipment, maintenance, operations of tools/equipment, depots and other matters with inter-site loans.

Question 16 was optional, for the participant project manager to add any comments or information from their own experience.

Some questions for some participants had no answers or were not applicable; for this reason, the analysis was not affected by questions unrelated to the project manager's speculation. Any blank question in the questionnaire has been treated as the respondent's inability to answer the question.

The first four options of (4, 3, 2, 1 and 0) express the strength of the answer of the respondent with respect to the issue. The first two shows the factor effect is severe, while the third and fourth show it is not so severe and the fifth shows no opinion. In addition, some questions such as 12, 13, 14 and 15 were sub-divided to further explain the causes of productivity gain or loss. The purpose of the sub-division was to give respondents a full picture of each type of factor. This gave respondents the opportunity to answer all causes. In general, the questionnaire was simple to administer and relatively easy to compile and analyse. Consequently, the frame of reference was specified in the response and this increased the chance of securing answers, which are relevant to the inquiry.

3.9 SAMPLING AND TARGET POPULATION

3.9.1 TESTING/SAMPLING

Casual testing/sampling is the best style of feasibility testing. For the pilot survey, each participant had a comparable opportunity of being a member; as long as the project's particular constraint was carried out. In contrast, the main survey clearly sampled project managers with a range of two to more than twenty years in their organizations in the Australian construction field (Fayek, Dissanayake & Campero 2003).

3.9.2 TARGET POPULATION

The pilot survey was based on construction and building projects that were achieved or half-finished in the last three years from 2008 to 2011 throughout Australia. Any project manager with good experience in Australian construction projects, however, could answer the main survey.

3.9.3 DATA COLLECTION CHANNELS

3.9.3.1 INTERNET

The pilot and main surveys were emailed to the prospective respondents (PM's).

3.9.3.2 REGULAR AUSTRALIA POST

All the participants for the main survey had a written survey delivered to them through the regular Australian post with stamped, self-addressed envelopes for the return of the questionnaire.

3.9.4 SURVEY PROCEDURES

3.9.4.1 PARTNERSHIP PREPARATIONS

The important preparation needed to select the participants was made in advance by the organizing committee of the Australian Institute of Project Management (AIPM) international conference in October 2010 in Darwin, Australia, for a proposed target organization (project managers). The questionnaire survey was discussed in detail with a considerable number of project managers in building management. The questionnaire was personally handed to them for answers and they sent it back by Australia Post.

3.9.4.2 PROCEDURES' TIME FRAME

Every one of the participants was given 14 days to answer the questionnaire survey followed up with an email or regular mail as a reminder and giving them an extra 14 days to complete the survey.

3.9.5 COLLECTING INFORMATION

Using the internet for conducting the survey, the response information was collected from the emails and kept in a confidential file with a special password for privacy and the respondents' security as well.

3.9.6 HARD COPY SURVEY COLLECTION

Australia Post sent the questionnaire survey and hard copies were handed directly to some respondents (a group of project managers) during the annual international conference for the Australian Institute of Project Management held in October 2010 in Darwin, Australia. All the responses collected from this conference and from the other direct mail were saved in a confidential file in a locked filing cabinet for the respondents' safety and identity confidentiality.

3.9.7 INFORMATION CLASSIFICATIONS

The gathered information was arranged for classification according to the following procedures:

- Unrestricted inquiries for example, an extra explanation, were classified as content.
- Ordinal level: the digits given to the concurrence order (4, 3, 2, 1 & 0) did not mean that the breaks among the rates were alike, nor do they display complete amounts and were explained as follows:
  - 4 – very serious problem
  - 3 – serious problem
  - 2 – minor problem
  - 1 – no problem and
  - 0 – no opinion.

The analysis treated these issues as numerical in order to develop the numerical relative index number (RII).

3.10 DELPHI METHOD

a) Delphi survey definition

The Delphi technique is well-organised communication technique used to evaluate the possibility and outcome of future events. The Delphi technique mainly advanced as a systematic, interactive predicting method, which relies on a group of experts exchange views. The experts answer questionnaires in two or more rounds and each individually gives estimates and assumptions to a facilitator who reviews the data and issues a summary report.

The Delphi method is an iterative process, and first goals to get a wide spectrum of ideas from the team of experts. The outcome of the first round of questions, when outlined, gives the ground for the second round of questions. The outcome from the second round of questions goes to the third round (Miller 2006).

The goal is to analyse and extend on matters and to identify areas of agreement/ disagreement and start to get consensus.

Delphi survey procedure:

It is necessary for the construction project manager to plan and predict what future events may influence the projects. These events could be positive or negative; this is will help the PM to put plans to overcome them. However, how is the PM predicting the future and what is the degree of certainty? Delphi Technique has the answer.

The Delphi Technique is a method used to estimate the likelihood and outcome of future events. A group of expert's exchanges views and each independently gives estimates and assumptions to a facilitator who reviews the data and issues a summary report (Eckman 1983).

The team members examine and review the conclusion report, and handed updated prediction report to the organiser/facilitator, who will review the report's material and issues a second report. These procedures are repeated until all participants reach a consensus.

The expert's group in every round have a complete report about the prediction of the other anonymous experts group. Anonymousness gives the members of the expert's group to precise their ideas openly.

The goal is to make clear and extend on issues, pinpoint the areas of agreement/ disagreement to start consensus (Cantrill & Sibbald 1996).

First: Selecting Organiser

Find a fair-minded individual within the organisation and should be familiar with research and data collection (Hill & Fowles 1975).

Second: Selecting the Experts team

The Delphi method depending on a team of experts. The team members could be a group of PM, the customer or other experts from within the organisation. An expert is any person with appropriate background and experience of a specific topic.

Third: Identify the Issue/Problem

The expert's group need to be familiar with the issue/problem they are examining it; therefore, they should get a complete explanation and comprehensive definition.

Fourth: Round One Questionnaire survey

General questions should be asked to get a wide understanding of the expert's perspective on specific aspects. The questionnaire will be sent to the participant in many ways for example email, Australian post or directly to the client. Collect the data and analyse the responses.

Fifth: Round Two Questionnaires survey

Depending on the information collected from the first questionnaire, the second questionnaire should dig harder and deeper into the matter to identify specific issues. The questionnaire can be sent in the same method as in the first round. In the same fashion, collect and analyse the results, and search for the common base to establish consensus.

Sixth: Round Three Questionnaires Survey

The final round of the questionnaire survey is focusing on advocating decision-making. Focusing on the issues of agreement (Issues all the experts are agreed on).

Seventh: Plan on the results/findings

After the last round of the questionnaire survey, a consensus could be reached and a view of future events became clear. Analyse the collected data and put the right plans to handle future opportunities and new circumstances to the project.

SUMMARY

Delphi Technique is used to constitute Work Breakdown Structures, recognising hazards/risks, and circumstances, accumulating tasks learned to be used in any problem-solving session.

Predicting the future events is not an accurate or precise technique/science, but the Delphi Method could help to understand the possibility of future events and what influence it might have on the project (Cantrill & Sibbald 1996).

3.11 SURVEY CIRCULATION

The intended participants in this research were project managers from different construction organizations and government departments in Queensland, Australia, selected randomly from about 1200 construction organizations out of almost 14,000 construction organizations in Queensland alone and in general the construction companies continues to have the most businesses operating, with 345,479 in operation in 2014-15 (Australian bureau of statistics , Feb. 2016, Australia).

Research method

This research is based on a survey designed to gather all necessary information in a productive way. The survey presents a number of productivity critical factors constructed on the ground of similar research study on construction productivity (Thomas & Sanders 1991; Guhathakurtal & Yates 1993; Lim & Alum 1995; Lema 1995; Olomolaiye et al. 1996; Heizer & Render 1996; Olomolaiye et al. 1998; Kaming, et al. 1998; Teicholz 2001; Wachira 1999; Rojas & Aramvareekul 2003), together with input, reviewing and alterations by some experts. These factors were classified based on prior literature review and as advised by some experts: Rework, Incompetent supervisor, Incomplete drawing, Work overload, Poor communication, Lack of material, Poor site conditions, A poor site layout, Overcrowding, Inspection delay, Absenteeism, Worker turnover, Accident, Breakdown and Lack of tools & equipment.

The research target population from the construction and building contractor’s from different firms in the construction industry. The essential criteria for classification are related to the construction firms' such as the previous experience; capital; the value/number of executed projects, staffing, and financial situation during the last few years.

An orderly random example was chosen to guarantee a typical example for the entire project manager group, applying the coming rule (Hogg & Tannis 1997; Cheung, Suen & Cheung 2004; Lyer & Jha 2005; Ugwu & Haupt 2007):

$$m= \{Z^2 P^* (1-P^*)\} / \varepsilon^2$$

&

$$n = \frac{m}{1+\{(m-1)|N)\}}$$

Where:

m – Sample size of unlimited population

n – Sample size of limited population

N – Total number of project managers (120)

Z – Value (e.g. 1, 85 for 95% confidence level)

P* – Degree of variance between the elements of population (0.5)

ε – Maximum error of the point estimate (0.05)

By substituting these values in the formulas above, we get the following values:

$m = (1.85)^2 \text{ X } 0.5 (1-0.5) / (0.05)^2 =342.25=342$

&

$n = 342 /\{1+[(342-1)/120]\}=89.024= 89$

Eighty-nine project managers from different organizations and companies within Queensland, Australia were scrutinised. The returned responses to the inquiry totalled 36 completed surveys, exhibiting a 40.4% response rate. All means such as email, direct contact with project managers and Australia Post were used to get these responses from the respondents. The respondents were among the most experienced PMs with ten years as project managers in their firms/organizations.

The random selection among the project manager was done by using non-replacement random selection. An ordinal measurement scale, which is a ranking of rating data that normally use integers in ascending or descending order, was used in this research. The numbers assigned to the agreement scale (4, 3, 2, 1 & 0) do not indicate that the intervals between the scales are equal, nor do they indicate absolute quantities (Naoum 1998). The respondents were asked to rank the factors affecting the construction productivity according to the degree of importance (4 – very severe issues; 3 – severe issues; 2 – small issues; 1 – no issues at all and 0 – no opinion). In analysing the data on an ordinal scale, a relative importance index (RII) was used to preference the severity of the aspects (See section 3.6.2).

3.12 ANALYSIS OF THE RESPONSES

Selecting a suitable procedure for analysing the collected data, the standard of the calculations should be accepted. For every case of the calculations, a suitable means should be used. In this present study, the number range was applied. A number range as indicated in Table 3.2 is a ranking of information that usually applies numbers in an escalating or downward range. The figure appointed in importance (4, 3, 2, 1 and 0) does not signal that the periods between the ranges are alike, nor do they signal complete numbers. They are only consecutive markers. Depending on the Likert gauge, Table 3.2 was created.

Table 3.2 Ordinal scale used for data measurement

Items	Very Severe Issues	Severe Issues	Small Issues	No Issues	No Opinion
Scale	4	3	2	1	0

3.13 SUMMARISING

This chapter of the thesis examines the target of the suitable methodology to be used in this research; the model choice in this investigation is as follow: a) Need a methodology to examine changes and a graduated system to analyse the occurrences. b) Apply statistical analysis for individual understanding using the Statistical Package for the Social Science (SPSS). c) Investigate to discover the data during the scientific study of motivation and ramifications. d) Seeks to discover knowledge through the scientific search for cause and effect.

The nature of this research suggests a quantitative methodology is most appropriate based on the above search requirements. A quantitative methodology also aligns with the fact that the majority of the research undertaken in construction management, engineering, and property uses quantitative methodology.

This research investigates in real time the main factor influencing the productivity of the construction industry in Australia, and includes research methodology and sampling techniques used to classify the greatest influences on productivity in the construction industry in Australia.

The former researchers concentrated on some aspects, for example:

- factors influencing the productivity of construction projects
- using different guidance such as expenses, time, or feature of achievement
- measurement of construction productivity
- different aspects related to productivity improvement.

The present goals, as mentioned above, need different methodologies. Here, the sampling questionnaire survey and the Delphi expert's technique are used.

A questionnaire was designed and the investigation was administered by a methodical survey, which was distributed to a group of skilled construction project managers in Australia. The questionnaire responses were evaluated by scoring on a zero to four Likert scale. The projects that were scored were then arranged utilizing a relative importance index (RII). The results were tabulated and ranked according to the values of RII in a descending order that has a relatively crucial impact on construction productivity.

This chapter handled the research strategy, the survey strategy, consensus-forming techniques, research framework for construction productivity, the methodology for this research (Objectives), data collection, and statistical methods.

The following chapter (Chapter 4) discusses the analysis of the data collected in Chapter 3, and ranks to the crucial factors affecting the productivity in the construction industry.

CHAPTER 4

THE STUDY RESULTS AND ANALYSIS

4.1 INTRODUCTION

This section of the study explains the characteristics of the participants and discusses the outcome of the survey carried out to answer the research questionnaire. As discussed in Chapter 3, the investigation included project managers (PMs) involved in construction projects in Queensland and Australia nationwide.

The project managers were supplied with the questionnaire and challenged with questions concentrating on their background and practices and limited to a specific project. This data was collected from parties directly involved with construction project management. The questionnaire was prepared and planned to gather information on the actual aspects of construction detracting from favourable outcomes and causing delays.

This investigation was done in two steps, as follows:

1. Step number one was the collection of data, which included reviewing related literature and gathering data through site visits for the pilot questionnaire and then the actual pilot questionnaire and discussions with different ranks of project managers.

2. Step number two focused on data study of the information collected during the census examination and identifying the most relevant factors causing construction productivity problems; this guided the development of the main survey that was delivered to a number of project managers in different projects with different capacities around Australia.

The questionnaire carried both the instructions and the questions to the participants and provided space for participants to write any comments. There were some considerations for both the subject content and the wording of each question in terms of shared vocabulary and clarity. Each question was stated in such a way as to be as exact, brief, clear and understandable as possible.

The survey consisted of two essential sections. The first section was an introduction in order to clarify the concept and the aim of the questionnaire (cover letter, consent form and the study at a glance. The second part, which was the main questionnaire, included questions 1 to 16 and included the following.

4.2 RESPONDENTS' CHARACTERISTICS

4.2.1 QUESTION 1: PROJECT MANAGERS' GENDER

Table 4.1 reveal that the respondents' gender was mainly male; the building businesses is commonly male-dominated, but during the past two or three decades women have begun to be involved in many different aspects of the industry and are achieving at a very high level within it.

Table 4.1 Project managers' gender

Gender	Frequency	Percentage	Valid percentage	Cumulative percentage
Female	0	0	0	0.0
Male	36	100.0	100.0	100.0

4.2.2 QUESTION 2: AGE OF PROJECT MANAGERS

Table 4.2 reveal that the majority of the project managers, almost 50%, were over 50 years of age and almost 47.2% were in the 30-to-50 age bracket. In the construction industry, artisans usually start work aged between 15–20 years, while engineers start after graduation at around 23 years of age. Older project managers and artisans have more experience in the construction industry.

Table 4.2 Project managers' age group

Age bracket	Frequency	Percentage	Valid percentage	Cumulative percentage
20 to 30 years	1	2.77	2.77	2.77
31 to 40 years	6	16.66	16.66	19.43
41 to 50 years	11	30.55	30.55	49.98
Over 50 years	18	50.00	50.00	99.98
Total	36	99.98	99.98	99.98

4.2.3 QUESTION 3: YEARS OF EXPERIENCE AS PROJECT MANAGERS

It is well known traditionally in the construction industry that it takes about a decade for a qualified engineer to become a good project manager and 15 to 20 years for a non-qualified, inexperienced supervisor to achieve sufficient experience to become a project executive (US Bureau of Labour Statistics, USA, BLS, 2013). Accordingly, it is acceptable that Table 4.3 show that 80.55% of the project executives had acquired minimums of ten to over twenty years of experience. This experience is expected to make the questionnaire reliable.

Table 4.3 Project managers' years of experience

	Frequency	Percentage	Valid percentage	Cumulative Percentage
2 to 5 years	1	2.77	2.77	2.77
6 to 10 years	6	16.66	16.66	19.43
11 to 20 years	14	38.88	38.88	58.31
More than 20 years	15	41.66	41.66	99.97
Total	36	99.97	99.97	99.97

4.2.4 QUESTION 4: PROJECT MANAGERS' QUALIFICATIONS

This question addressed qualifications; within the construction industry, there are three main ways to be promoted to project manager.

The first is the traditional approach for a non-qualified person to gain at least 15 to 20 years of experience through a trade career.

The second is to work as an engineer and get promoted over the years (site engineer, project engineer, senior project engineer, then assistant or deputy project manager and finally project manager) until the necessary experience is gained, or to undertake management studies through Australian universities such as the University of Southern Queensland (USQ), Australian Institute of Project Management (AIPM) or institutes of Technical and Further Education (TAFE).

The third is to obtain a qualification such as a Diploma or Certificate IV in Construction Management from a vocational college such as an institute of TAFE or a tertiary education such as the University of Southern Queensland (USQ) or Queensland University of Technology (QUT) in project management or construction management plus on-site experience for a number of years to be promoted to project manager.

In this survey, the results were 38.88% qualified with master's degrees, 41.66% with bachelor's degrees, and 19.44% with technical degrees. None held a doctorate. These percentages represent a very high standard for the project managers surveyed.

Table 4.4 Project managers' level of education

Type of education	Frequency	Percentage	Valid percentage	Cumulative percentage
Technical/vocational college	7	19.44	19.44	19.44
University bachelor's degree	15	41.66	41.66	61.10
University higher degree	14	38.88	38.88	99.98
Total	36	99.98	99.98	99.98

4.2.5 QUESTION 5: EMPLOYMENT EXPERIENCE

This addressed the issue of employment experience in different areas of the construction industry such as residential, commercial, industrial, civil, infrastructure, and its general effect on construction productivity.

From Table 4.5(a) it is clear that in the residential construction subdivision, the percentage of the project managers' experience was high, between 1 and 5 years (19.4% to 22.2%), but from 6 to 10 years the percentage was lower (16.7%). Project managers with 11 to 20 years of experience were 8.3% to 11.1% respectively. This means that project managers have enough experience in the residential construction sector. In the commercial, , the percentage of project managers' experience was high between 6 years and over 20 years (33.3%, 30% and 26.7% respectively); however, industrial was (44.4%, 16.7% and 22.2%) for the same period, and the civil sector, the PMs' experience percentage was 31.3% for the period of 2 to 5 years, but from 10 to 20 years' experience the percentage was 18.8%. Finally, the majority of project managers had over 20 years of experience, representing 31.3%.

Some project managers were working for different employers such as government departments, public servants, water and sewerage departments and electricity supply companies, which give them more working experience in a different field (Table 4.5b). Overall, the project managers in all four-construction sectors had considerable experience in one or more sectors of the construction industry. This experience is expected to make the questionnaires reliable.

Table 4.5 a Project managers' working practices in area of building and structures type

Type of construction	Years of experience						Total
	Percentage	0 to 2 years	2 to 5 years	6 to 10 years	10 to 20 years	Over 20 years	
Residential	Percentage	19.4	22.2	16.7	8.3	11.1	77.7%
Commercial	Percentage	6.7	3.3	33.3	30.0	26.7	100%
Industrial	Percentage	11.1	5.6	44.4	16.7	22.2	100%
Civil	Percentage	12.3	31.3	6.3	18.8	31.3	100%
Other	Percentage	20	40	10	30	0	100%

Table 4.5 b Project managers' other working experience

Type of work	Frequency	Percentage	Valid %	Cumulative percentage
Government	33	91.7	91.7	91.7
Public servant	1	2.8	2.8	94.4
Water/sewerage	1	2.8	2.8	97.2
Electricity supply	1	2.8	2.8	100.0
Total	36	100.0	100.0	100.0

4.2.6 QUESTIONS 6,7 & 8: PROJECT MANAGERS' LENGTH OF STAY

These questions specified the project managers' period of work with the present institution, number of project managers who had left their jobs since the project manager was hired, and the methods of quitting their formal post, accordingly. 61.11% of the project managers had worked for their present institution for at least 6 years (Table 4.6 a, while only 22.2% of project managers identified that more than eight project managers had quit since they established their appointment (Table 4.6 b) in addition to 63.9% who resigned from their former job of their own accord (Table 4.6 c). This data reflects the issues of loyalty and commitment to their employers and their organizations and, importantly, whether their stability in the job greatly affects construction productivity.

Table 4.6 a Project managers' length of stay with current employer

Number of years	Frequency	Percentage	Valid Percentage	Cumulative percentage
Less than 2 years	3	8.3	8.3	8.3
2 to 5 years	11	30.6	30.6	38.9
6 to 10 years	9	25.0	25.0	63.9
11 to 20 years	5	13.9	13.9	77.8
More than 20 years	8	22.2	22.2	100.0
Total	36	100.0	100.0	100.0

Table 4.6 b How many other project managers have left the organization?

Number of project managers who have left	Frequency	Percentag e	Valid percentage	Cumulative percentage
0 to 2	15	41.7	42.9	42.9
3 to 5	6	16.7	17.1	60.0
6 to 10	6	16.7	17.1	77.1
More than 10	8	22.2	22.9	100.0
Total number of PMs who have left	35	97.2	100.0	
Missing system	1	2.8		
Total	36	100	100	100

Table 4.6 c How project managers left their previous job

Ways the project managers left their job	Frequency	Percentage	Valid per-cent age	Cumulative percentage
1 – Left of own accord	23	63.88	63.88	63.88
2 – Employer's proposal	4	11.11	11.11	74.99
3 – This is my first job	2	5.55	5.55	80.54
4 – Other; please specify	7	19.44	19.44	99.98
Total	36	99.98	99.98	99.98

From the above tables and figures numbered 4.6 a, 4.6 b and 4.6 c, all the data shows that the project managers had fairly high commitment to their organizations, which would be reflected in project schedules, i.e. work would be done on time without delay and without extra cost because of the project management stability on the job. All these would have significant effects on the site's productivity.

4.2.7 QUESTION 9: TYPES OF CONTRACTORS AND NATURE OF WORK

This question covered the types of contractors and the essence of the project performed by the involved institutions, accordingly. 78.1% were general builders, while 3.1% and 18.8% were subcontractors and in other types of construction, works such as designing, developer/builder, engineering firm, government, PM client and public utilities (Table 4.7 a & 4.7 b).

Table 4.7 a Types of contractors of project managers' organizations

Type of contractor	Frequency	Percentage %	Valid %	Cumulative %
General contractor	25	69.4	78.1	78.1
Subcontractor	1	2.8	3.1	81.3
Other	6	16.7	18.8	100.0
Total	32	88.9	100.0	
Missing system	4	11.1		
Total	36	100.0		

Table 4.7 b Details of other work done by project managers

Other work performed	Frequency	Percent	Valid percent	Cumulative percent
Valid	28	77.8	77.8	77.8
Design office	1	2.8	2.8	80.6
Developer/builder	1	2.8	2.8	83.3
Engineering firm	1	2.8	2.8	86.1
Government	1	2.8	2.8	88.9
N/A	1	2.8	2.8	91.7
PM client	2	5.6	5.6	97.2
Public utility	1	2.8	2.8	100.0
Total	36	100.0	100.0	100.0

4.2.8 QUESTION 10: NATURE OF PROJECT MANAGERS' ORGANIZATIONS

The project manager's organizations were performing the following construction projects, leaving the investigator to decide whether the data collected was trustworthy or not because of the variety of different construction work, especially civil work, which represents the major percentage of 72.20%, so these projects were strongly related to the survey questionnaire. From among the 36 respondent project managers, 72.2% were involved heavily in civil engineering projects, while their institutions had minimal involvement in the residential area, only 2.9%, although in the industry sector included 8.6% and 14.3% were involved in commercial construction.

Table 4.8 Nature of the work of project managers' organizations

Type of work	Frequency	Valid percentage	Cumulative percentage
Residential	1	2.9	2.9
Commercial	5	14.3	17.2
Industrial	3	8.3	25.5
Civil	26	72.2	97.7
Missing system	1	2.8	100.00
Total	36	100	100

4.2.9 QUESTION 11: PROJECT MANAGERS' OPINIONS ABOUT THEIR EMPLOYERS

This question asked project managers' opinions about their employers and subordinates (in relation to efficiency, friendliness, teamwork, communication, meeting deadlines), the work surroundings, and the common wages, as these factors have a direct relationship with construction productivity. The project managers were requested to provide their opinions of their organizations, assistance, work surroundings and common wages by rating their assessment on a five-point Likert ladder from 5 (very good), 4 (good), 3 (fair) and 2 (poor) to 1 (very poor) (Table 4.9). The majority of respondents who answered the question were happy with their organizations and their assistance, and a small percentage were unhappy with their work surroundings (i.e. it was not often ranked as inadequate or very inadequate). However, only 66.7% of the participants believed that their salaries were satisfactory (i.e. they were ranked acceptable or very acceptable). This level of the project managers' satisfaction is very important because it boosts stability on the job and has a very positive effect on site construction productivity.

Table 4.9 Project managers' opinions about their employers

	Very Good%	Good %	Fair %	Poor %	Very Poor %	No opinion %	Remarks
Opinion about the employer	38.9	44.9	2.8	5.6	8.3	0	
Subordinate efficiency	11.1	12.2	13.9	2.8	-----	0	
Subordinate friendliness	27.8	63.9	2.8	5.6	-----	0	
Subordinate communication	19.4	52.8	25	2.8	-----	0	
Subordinate meet deadlines	13.9	61.1	22.2	2.8	-----	0	
Subordinate teamwork	30.6	50	16.9	2.8	------	0	
Work environment	30.6	52.8	11.1	5.6	------	0	
Level of payment	16.7	66.7	13.9	2.8	-----	0	
Other(please specify)	2.8	2.8	-----	-----	2.8	0	

4.2.10 THE MAIN ASPECTS WHICH BEAR NEGATIVE EFFECTS ON THE CONSTRUCTION PRODUCTIVITY

Question 12 addressed the main factors that have been shown to bear negative effects on the building work rate, in addition asking respondents to rate the significance of various issues such as incomplete drawings, breakdowns of instruments and machinery, rework, incompetent project managers and supervisors, absenteeism and work turnover, work overload, poor site conditions and layouts, site overcrowding, inspection delays, accidents, poor communication and lack of materials. For example, the shortage of building components is the most powerful factor affecting building work rates in general. This is plausible because the building components are very important for finishing any procedure on time in the construction process. In addition, all the project procedures are normally related, so if the building components run short for a specific project, this will affect the next procedure. On the other hand, if there is a shortage in the project necessities as decided during the project continuation, the project will deteriorate from problems such as the time duration for construction and the financial performance. These problems could be minimised if the necessities for the project, for example, time, and cost, improved (Table 4.10 a).

Table 4.10 a Project Manager’s opinion about Factors affecting the construction productivity in Australia

Rank	Factors	Ranked score 0	1	2	3	4	Total #’s	Total Scores	RII
1	Rework	0	1	2	5	28	36	132	0.92
2	Incompetent supervisor	0	2	1	7	26	36	129	0.90
3	Incomplete drawing	1	2	06	14	13	36	108	0.75
4	Work overload	0	5	14	14	3	36	87	0.60
5	Poor communication	0	2	24	5	5	36	85	0.59
6	Lack of material	0	4	20	8	4	36	84	0.58
7	Poor site conditions	0	8	20	6	2	36	74	0.51
7	A poor site layout	0	8	20	6	2	36	74	0.51
7	Overcrowding	0	8	20	6	2	36	74	0.51
7	Inspection delay	1	13	11	6	5	36	73	0.51
8	Absenteeism	0	7	22	7	0	36	72	0.50
8	Worker turnover	0	7	22	7	0	36	72	0.50
9	Accident	0	8	25	3	0	36	67	0.47
9	Tools / equipment breakdown	0	8	25	3	0	36	67	0.47
9	Lack of tools and equipment	0	8	25	3	0	36	67	0.47

Table 4.10 a presents the relative importance index (RII) examination and determinations of the aspects influencing the productivity and their promise for advancement. Aspects that influence the building productivity were collected from a literary study of previous research (Megha & Rajiv 2013; Rojas & Aramvareekul 2003 a; Heizer & Render 1996; Olomolaiye 1990; Kaming 1998; Olomolaiye et al. 1996; Teicholz, Goodrum & Haas 2001; Wachira 1999). In the survey for this research, the project managers were requested to give their opinions of these aspects, which were rated by applying the RII, as shown in Table 4.10(b). If the RII value is bigger than 0.5 this shows that the participants ranked the aspects as having greater than limited effects on the building work rate and vice versa (Muhwezi, Acai & Otim 2014) , as in the following explanation.

In this study, 40 aspects influencing the construction productivity have been recognised from the standard survey and the Delphi survey and have been assessed by a team of expert project managers. These aspects were layered within the essential 15 primary aspects and 25 secondary aspects respectively. Participants were requested to rank the chosen aspects influencing the building productivity by applying a Likert gauge (Holt 2014; Makulsawatudom, Emsley & Sinthawanarong 2004). The aspects were then rated by involving the RII (Lim & Alum 1995). In this ranking, 15 aspects were evaluated as holding average or greater influence on the construction productivity. Similar examinations and determinations were administered to the secondary aspects.

Table 4.10(b) focuses on the following factors: rework; incompetent project managers and supervisors; incomplete drawings; lack of materials; work overload; poor communication; poor site conditions, overcrowding and layout; examinations and check-up delays; defections and desertions from work; accidents, device and machinery failures and shortages. These factors are discussed in more detail in the following sections.

Table 4.10 b Aspects influencing work rate /productivity in the construction industry in Australia

Factors	V. Serious Problem %	Serious problem %	Minor problem %	No Problem %	No opinion %	Remarks
Lack of Material	8.6	22.9	57.1	11.4	-----	
Incomplete Drawing	36.1	38.9	16.7	5.6	2.8	
Breakdown of tools and Equipment	------	8.3	69.4	22.2	------	
Rework / Incompetence	8.3	19.4	58.3	11.1	------	
Absenteeism / Worker turnover	-----	19.4	61.1	19.4	------	
Work overload	8.3	38.9	38.9	13.9	-----	
Poor site Conditions / Overcrowding and layout	5.6	16.7	55.6	22.2	-----	
Inspection delays	13.9	16.7	30.6	36.1	2.8	
Accidents	8.3	8.3	47.2	33.3	2.8	
Poor Communication	13.9	13.9	61.1	11.1	-----	

4.2.10.1 REWORK

Structured activity always suffers from expenses that go over the limit and rework is the greatest aspect leading to expense overruns. Investigation by the Construction Industry Institute (CII) shows that explicit expenses created by rework or alteration averaged 5% of the total project budget (Construction Industry Institute 2005). The US building sector exhausted $1502 billion in 2004 for the entire installation costs (USA Bureau of Economic Analysis 2006), and around $75 billion was exhausted on straightforward expenses created by rework and alterations in that year only. Accordingly, rework and alterations should be treated as a very critical issue causing expenses to rise high and delay the building industry.

Many in-depth studies (Holt 2014; Fayek, Dissanayake & Campero 2003; Love, Yoklavich & Thorsteinson 2002 a; Love & Edwards 2004) have tried to classify the core elements of rework and alterations to measure their general magnitude. These researchers discussed that rework and alterations are necessary because of unpredictability, lack of supervision, ineffective communications, and useless opinions.

Rework is defined as required activity of rework of procedures or activities that have been carried out incorrectly the first time. Likewise, site rework and alterations are classified as extra works that have to be carried out more than one time or actions that take off some works formerly done as a section of the main project (Construction Industry Institute 2001). Based on the CII's definition, Fayek, Dissanayake & Campero 2003, suggest classifications for rework and alterations that suggest those caused by extent adjustment and changed commands from owners should not be classified as rework. Therefore, rework and alterations can be identified as redoing of activity because of non-conformance with necessities.

In this research, the rework factor, with a RII of 0.92, is number one critical factor affecting construction productivity (table #5.7). The more rework, the more time and costs are incurred. In addition, it will cause delays for other aspects of the project and make the project fall behind the finishing time and the schedule. Rework is needed because of incompetent PMs, supervisors and artisans.

On the other hand, inadequate operations skills and insufficient background in the reading of blueprints and plans are good indications of inefficient artisans, but deficiency in working practices and skills is an indication of unskilled project managers and supervisors. Other causes of rework are changed orders and incomplete drawings. These two factors alone cause time delays and cost overruns and so reduce productivity. Nevertheless, the respondents listed unskilled project managers and supervisors as the main causes of the main reason of rework, as particularised in the previous section.

4.2.10.2 INCOMPETENT SUPERVISORS

This aspect is rated second regarding its effect on building productivity, with a RII of 0.90. Unskilled supervisors have poor performance and could be liable for damaged work and unsuitable operation of devices and machinery. The main aspect for causing incompetence on the construction site is poor administration, therefore, unskilled tradespeople are advanced to a higher position than they deserve, then to a managerial position. Construction productivity could be developed and enhanced if management provided on-site practice and practical training with many considerations when selecting supervisors (Heizer & Render 1990).

The aspect of unskilled supervisors is ranked highest of all the indicators and this might be the case, but is not likely to be completely so because of the neglect on the part of the supervisors to enrol in training and attend refresher courses. The majority of the supervisors were previously trained but they did not continue after leaving school, although some were keen enough to carry out on-site training. This is just one factor among the many necessities of being a supervisor (Naoum 2016). Therefore, it is very important to construction institutions to play a vital role in continuing training programs for the artisans, supervisors, and superintendents as on-site training or sending them to tertiary education institutions. Some other factors are that they might be insufficiently trained and unprepared to perform projects. Unskilled supervisors influence many more other projects (Alinaitwe, Mwakali & Hansson 2007).

Table 4.6 a shows the length of stay of supervisors and project managers with their current employers. For example, in the first survey (the standard survey), question six is examining the project managers' length of tenure with their current employers. The survey response shows that there is a reasonable degree of turnover of project managers, with about 36% remaining with the firm for more than 10 years, and 39% leaving within five years.

On the other hand, table 4.6 b shows the number of project managers who resigned since the proposed project manager joined the company. (42%) stated that no more than two project managers had left their organization since they commenced work. Eight (22%) stated that more than 10 project managers had left since they were recruited. In addition, the survey shows that 64% left by own accord, 11% left upon employer proposal's, 5.6% was their first job, but 19.4% resigned for other reasons (not specified).

The benefit of staying longer with the current organization is due to the fact that the longer that supervisors and project managers stay with their current employers, the more experience they will gain and they will become more familiar with their employer's rules and regulations, the types of work and the employer's productivity plan. When project managers stay with their current employers they are provided with more incentive and better remuneration in the long run.

4.2.10.3 INCOMPLETE DRAWINGS

The respondent project managers recognised that incomplete drawings have heavy effects on the construction work rate, creating delay for reviewing or interpretation of drawings and requirements. For that reason, it was rated the third most crucial factor, with a RII of 0.75, proving that unfinished drawings are an additional major construction productivity obstacle in Australia.

Since unfinished drawings prevent projects from progressing smoothly because of the delays for reviewing or interpretation of drawings and requirements, therefore all these aspects have severe influence on the construction productivity (Table 4.10 a). The reason behind this aspect is the clients' restricted schedules and their financial plans for the design engineers to carry out the planning and designing for accelerating the job’s procedures, and/or errors on behalf of the architecture division of an organization that is performing poorly or scheduling improperly. However, to find an explanation for this aspect, the canvassed project managers were requested to rate the common reasons for incomplete drawings, depending on their activity background (Enshassi et al. 2007); the results are exhibited in Table (4.10 b).

In respect of the possibility for improvement, the project managers felt that if clients provided more time and budget to designers, and gave final drawings approval before the invitation to bid took place, and if designers spent more effort in providing details of drawings, these problems would be easily overcome.

4.2.10.4 LACK OF MATERIALS

Shortage of materials has a rating RII of 0.58 and is ranked as the sixth factor, although in most previous surveys in the last 15 years it was ranked the number one factor affecting construction productivity in many countries such as Thailand, Indonesia, Iran, Nigeria, the UK and the USA (Naoum 2016; Megha & Rajiv 2013; Kaming et al. 1997 a; Zakeri et al. 1996).

This rating is plausible because construction and building materials components are very significant for all projects. In addition, since projects always relate to each other, if there is a shortage in the construction materials for a specific project, this will influence the next procedure and will cause a significant delay in the project delivery. To investigate the matter further for this aspect, the canvassed project managers were requested to rate the common reasons for materials shortages according to their working background; the outcome is represented in Table 4.11 a. Shortage of materials with a RII rating of 0.58 is highlighted as one of the severe aspects affecting the construction work rate and is ranked as the sixth factor (Table 4.10 a). This is not surprising, as construction materials are crucial for construction projects. The project managers disclosed that the problem with the shortage of materials is essentially because of contractors’ liquidity problems, so a number of contractors do not have enough finances to obtain essential materials.

In addition, when suppliers have previously experienced late payment, they may withhold delivery until payment has been made. The project managers also mentioned in their responses that the shortage of material might be because of an incompetent project manager who commits inadequate priority to materials obtainment. In addition, such project managers have not enough information about materials, including suitable replacements. Some other reasons have been specified, such as imported material and inadequate coordination between the construction site and the head office. Unlike its effect on productivity, lack of materials was rated sixth, with a RII of 0.58, regarding its potential for improvement. The project managers advised to ask the applicants to make advance instalments as soon as the materials have been dispatched, enforcing good working relationships with suppliers and testing materials to be introduced at material administration meetings to develop coordination between the construction site and head office.

4.2.10.5 WORK OVERLOAD

With a RII of 0.60, this is rated as the fourth aspect influencing construction productivity. Lengthened working hour schedules (work overload) are usually applied to replace a larger squad, in order to accelerate the building activities or to invite extra labourers and tradespeople to sites with a labour shortage. This will affect the activities on another site (usually tradespeople are counting on overtime in order to make more money) and will overrun the labour cost of the project. If the construction workers are working seven days per week with no break, it will have a dramatic impact on the workers' productivity, but if they work a few extra hours through the normal working hours, it will have a moderate impact. Enshassi et al. (2014) and Hinze (1999) confirmed this conclusion and stated that, working extra days and hours has an adverse effect on workers' productivity. These conclusions are not unexpected, because working extra days and hours will have a negative impact on the inspiration, natural stamina, and mental power of workers, so decreasing the productivity. Nevertheless, the effects of working long hours for a short cycle might be not negative. This outcome also represents that abuse of time schedules has a higher adverse influence on workers' productivity.

4.2.10.6 COMMUNICATION ISSUES

With a RII of 0.58, this is ranked as the fifth factor and considered a critical factor affecting construction productivity. This aspect could permit damaged work to exist due to lack of communication skills. On the other hand, the building timetable could be essentially held up as a result of lack of communication. In addition, the deferred timetable will have a severe impact on the overheads and the total expenses.

Poor communicated data and instructions can cause defective work, which subsequently needs to be reworked or altered. Generally, it requires a fraction of confusion and error to cause a serious project setback.

Research on building work rates in Thailand, which implied the same basic aspects influencing the construction work rate as those applied in this study, noted that lack of communication skills in the workplace caused damaged and poor-quality work to be done. The research recommended that casual unwritten communication should be replaced by documentation, for example, project activity operations, standards, blueprints, and guidance (Makulsawatudom et al. 2004; Megha & Rajiv 2013). Modern electronic communication means such as mobile phones are anticipated to connect the project parties in a construction project instantaneously and overcome many problems such as designing plans and documenting data, specifically when a number of parties are implicated in action (Thorpe 2003).

In general, a lack of communication skills is causing adverse effects in many areas of our lives, whether our private or practical lives. Accordingly, if communication is inadequate, many factors in our lives cannot be understood clearly and this ultimately results in some failures.

4.2.10.7 POOR SITE CONDITIONS, POOR SITE LAYOUT, OVER CROWDING

A poor site condition with a RII of 0.0.51, this is rated as the seventh aspect influencing construction productivity. The effects of poor site conditions vary from site to site and may lead to working difficulties and unsafe working conditions; consequently, accidents may occur, which causes delay. Poor site preparation is the only cause of this factor as revealed by the project managers.

In addition, poor site layout and site overcrowding were both ranked as number 7 with a RII 0.51.

Site conditions are often a natural phenomenon mostly outside the project managers' control; however, the respondents suggested that site preparation, such as ground levelling and installation of lighting and firefighting systems, should be compulsory and would significantly decrease the effect of poor site conditions on productivity.

Some large construction companies have a complete division for site safety, site preparation, and site planning to secure safety, smooth trafficking, and flow on the site; however, small companies hire safety companies to look after their site safety issues when they start a new project. These procedures are very important to save project time delays and to eliminate financial pressure on the project's budget due to work compensation and litigations.

On the other hand, the majority of facility managers are instructed to cooperate face to face with the junior contractors who are involved directly in some construction work and activities such as conservation, transformation, and cleansing of the material of the infrastructure. Progressively the accomplishments of junior contractors depend on the manager of the facility, therefore comprehension of the procedures is recommended. It is necessary for all contractors to supply a secure and protected work surrounding for the staff, labourers, and subcontractors. Therefore, occupational health and safety (OH &S) is a very important matter for corporations and firms essentially because of the fear of prosecution.

The commencement of nil resilience by the Victorian Work Cover Authority in 1999 implemented higher OH &S security rules for the construction industry. These extra safety rules increased the stress, anxiety, and concern of construction and affiliated firms, specifically the junior ones with limited financial condition; in addition, it was found that company size is a major factor in the OH &S accomplishment of a construction company. An investigative study was conducted depending on the reference point of 44 construction companies in Victoria, Australia. The outcome of the study proved that the main aspects affecting safety acts were the firm's size, administration and the staff obligations to OH &S (Lin & Mills 2001).

4.2.10.8 EXAMINATION DEFERMENT OR INSPECTION DELAY

Participants rated this aspect seventh regarding its influence on productivity, with a RII of 0.51. Examination deferment usually causes delay in work progress and also affects sharply any process in the critical/detracting area. The project managers additionally stated that the reasons behind inspection delays are unskilled project managers and supervisors, for example, those who cannot differentiate between jobs ready to be inspected, cannot preference jobs for deferment or do not simplify the mutual efforts among the contractors and inspectors, adding to that careless and reckless inspectors, for example, inspectors who are not punctual and abuse their power and neglect their work.

In addition, work inspection by project managers and supervisors is an essential process for keeping up progress; for example, contracting firms are not allowed to cast concrete without inspector certification of the formwork and steelwork. Therefore, inspection delays contribute to stagnation in construction procedures and activities.

Similar to the shortages of materials, although this aspect has great impacts and an important influence on the work rate, the respondent project managers expected this result, as they believe that this factor is largely outside their control. Their only advice was that a project manager should pay special attention to jobs on the critical path (Enshassi, et al. 2007).

4.2.10.9 ABSENCE AND WORKER TURNOVER (LABOUR SITE DESERTION)

With a RII of 0.50, both of these are rated as the eighth aspect influencing construction productivity in Australia. Absence and labour site absenteeism in the construction industry have actually been higher than in any other reliable industry. These mean an increase in training costs, changing workforces, incompetent preparations by superintendent and workers' immoral issues; these factors in total decrease the productivity, and interrupt the activity timetable. On the other hand, absence of supervisors delays the scheduled and in-progress works that need their presence, for example, pouring concrete for reinforced steel foundations, reinforced steel beams, and reinforced steel concrete slabs. Furthermore, the supervisor's absence causes interruption in the examination of prepared works, and so brings interruption to starting a fresh project. Construction industry researchers hope to recognize the aspects, which lead to absence and labour absenteeism, and to suggest some methods to minimize these (Enshassi et al. 2007).

4.2.10.10 ACCIDENTS, TOOLS, EQUIPMENT BREAKDOWNS AND LACK OF TOOLS AND EQUIPMENT

Although undesirable events on the construction site such as an accident have severe effects on workers' productivity, in this survey this aspect is rated ninth with a RII of 0.47 as in Table 4.10 b. There are a number of types of accidents, such as accidents leading to a worker's death, accidents that cause an injured labourer and minor injuries from nails and other objects; all kinds of accidents affect productivity to a certain degree (Sheahan et al. 2005).

Lack of tools and equipment and its breakdown are playing a very important part in construction works; without the devices and machinery, construction work cannot be carried out continuously to the necessary standard or it will be much stagnated. This aspect were rated ninth, with a RII of 0.47, and is generated due to poor management, such as lack of supply of tools, inexperienced maintenance programs causing wasteful operations, the application of obsolete machinery and devices in addition to a lack of extra and reserve parts. On the other hand, an unskilled project manager who exaggerates the ability of a machine leads to inadequate numbers of the machines being used. Implementation of preventive maintenance is highly recommended, as maintenance cost is limited if distinguished from the expense that occurs when devices and machinery break down (Dingsdag, Sheahan & Biggs 2006).

4.2.10.11 CHANGING ORDERS/ARRANGEMENTS

From time to time, a repeated changing arrangement is wanted by the proprietors or the stakeholders in response to a request from the project top management. Proprietors/stakeholders want to reduce changing orders/arrangements during the structured works to eliminate productivity interruption. Some changing arrangements planned by project managers aim to reduce expenses on extra activities. One of the main aspects influencing construction project productivity and causing overruns in both the cost and the delivery time is variations. Other causes include the workers being kept in the dark without proper explanations and without updates; technological practicability research attempted ahead of the project approval is incompetent; the proprietors instructions for changing orders are mostly decided through brief observation, thereby affecting the construction schedule. Sometime the changing orders make a heavy request such as re-designing or large alterations (Arditi & Mochtar 2000). The project managers ranked design mistakes initiated by the architects as the most significant factor to changing orders/arrangements. That fact shows that some projects are rushed to start through another board overriding the itemised development of the project's program. Many efforts have been made so far to reduce or eliminate the influence of differences or variations.

The following explanation regarding the factors in questions 13, 14 and 15 of the questionnaire are for extra clarification in relation to the factors affecting the construction productivity in Australia

4.2.11 QUESTION 13: THE CAUSES OF LACK OF MATERIALS

This question covered an extra aspect influencing the construction productivity in general and in particular: the cause of shortage of construction material (referring to Table 4.11 b, Section 4.2.11 and Section 2.25). It was ranked as the sixth aspect with a RII of 0.58 as in Table 4.11 a. This is plausible because the building components are the backbone of any works and without them, all the construction works will stagnate. The project managers disclosed that the problem with the shortage of material is essentially because of contractors' financial issues; some construction firms suffer from major financial difficulties in acquiring the needed building material (Heizer & Render 1990).

Devices and machinery are essential for construction work, because without devices and machinery, no work will be achieved or done continuously or to an acceptable standard. For that reason, this aspect was rated fourth, with a RII of 0.50. Furthermore, the factor of improper application of tools and equipment is ranked sixth with a RII of 0.46 as a major influence on the construction productivity. Examples of improper application of tools & equipment is using a damaged device at a site, using a measurement gauge to get rid of debris rather than using a debris hammer, which will damaged its efficiency, applying French wrench rather than using a hammer, which will cause loosening of its tuner; all these show that shortages of the right devices and machinery are an additional detracting aspect that influences the construction productivity in Australia (Kaming et al. 1997 b).

Not using the right devices and machinery is the result of project administration inexperience with maintenance programs, which creates ineffective application of devices and machinery, use of outdated devices and machinery, lack of new components or project managers exaggerating the ability of machines, leading to inaccurate numbers of equipment on the site (Adrian & James 2002). However, to examine the factor of tools and equipment influencing construction productivity, the project managers were requested to rate normal reasons for shortages of devices and machinery from their building work knowledge; the conclusions are presented in Table 4.11 b and Figure 4.11 b.

Other reasons are poor organization and poor coordination between the site and head offices. In addition, negligence/sabotage and waste with a RII of 0.46, this is ranked #6 in Table 4.11(b). An example of materials wastage because of worker negligence is when, for example, instead of looking for a suitable dimension of steel sheet, the worker uses a brand-new steel sheet. Operational damage is when workers intentionally damage or sabotage materials, usually because of their discontent with poor treatment from the administration or with their salaries (Adrian & James 2002).

In order to improve this situation, the manager should pay an advance instalment of money upon materials delivery, apply an enhanced series of activities, investigate the building components' suitability for use, and establish material administration meetings to develop coordination between the construction site and head offices. Other causes include inadequate planning, misuse because of negligence, improper materials depository, improper transport of materials to the work site, poor planning of the transportation causing difficulties on the construction site, fluctuations in availability, improper material usage to the standard, improper material handling on site, and excessive paperwork (Eddy & Peerapong 2005).

To examine the reasons for all these factors, the canvassed project managers were requested to rate the common reasons causing lack of materials. Although lack of materials with a RII of 0.58 was rated as the sixth factor, in most previous surveys over the last 15 years it was ranked as the number one aspect influencing the construction productivity in many countries. In this survey, lack of materials also has a severe impact on the construction productivity (Jiukun, Goodrum & Maloney 2007), as explained in Table 4.11 a and Figure 4.11 b.

Table 4.11 a Project managers' opinions about material unavailability (Q 13)

Factors		Rating in percentage					Remarks
		V. Serious problem	Serious problem	Minor problem	No problem	No opinion	
1	Shortage of funds	5.6	63.9	22.2	-----	2.8	
2	Waste due to negligence/sabotage	-----	13.9	52.8	27.8	-----	
3	Improper materials storage	2.8	5.6	61.1	25	-----	
4	Improper delivery of materials to site	5.6	8.3	58.3	22.2	-----	
5	On- site transportation difficulties	2.8	19.4	41.7	30.6	-----	
6	Fluctuation in availability	-----	22.02	58.3	13.9	-----	
7	Inadequate planning	13.9	41.7	30.6	8.3	-----	
8	Improper material usage to specifications	5.6	16.7	55.6	16.7	-----	
9	Improper material handling on site	2.8	13.9	52.8	22.2	-----	
10	Excessive paperwork to request	11.1	19.4	44.4	16.7	-----	

Figure 4.11 a Project managers' opinions about material unavailability

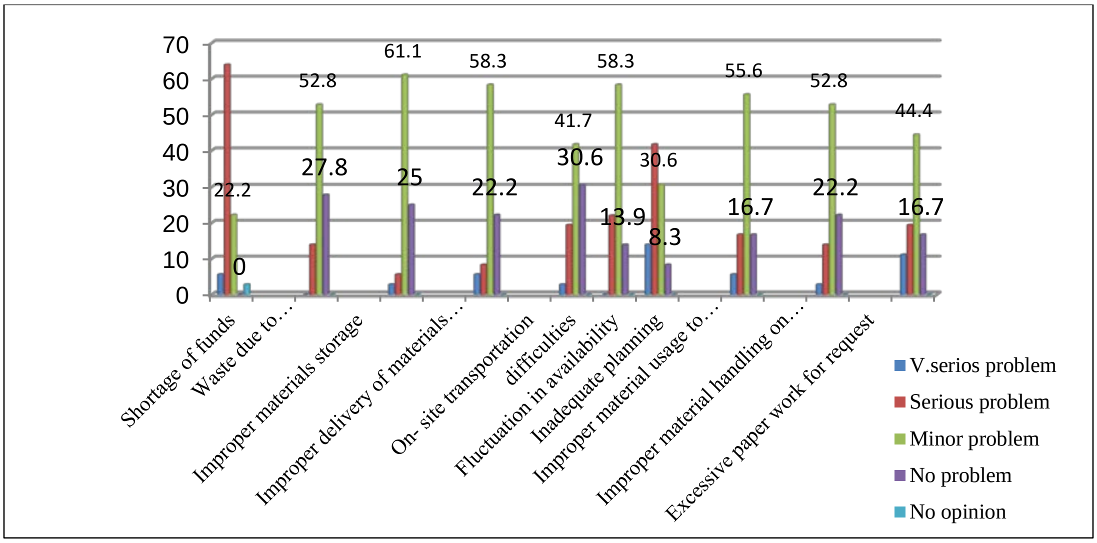
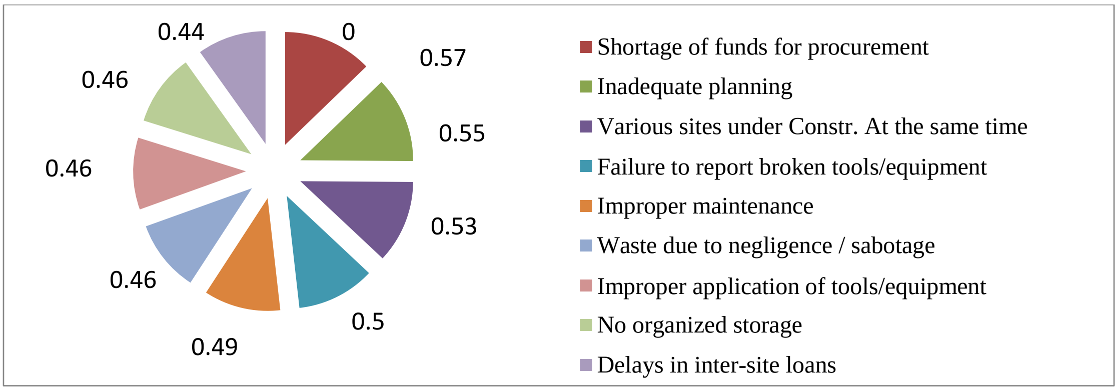


Table 4.11 b RII for project managers' opinions about material unavailability.

Rank	Factors	Ranked Scores					Total Number	Total Scores	RII
		0	1	2	3	4			
1	Shortage of funds for procurement	0	8	10	14	2	34	78	0.57
2	Inadequate planning	0	8	14	9	3	34	75	0.55
3	Various sites under Constr. At the same time	0	8	13	13	0	34	73	0.53
4	Failure to report broken tools/equipment	0	11	13	8	2	34	69	0.50
5	Improper maintenance	0	6	24	3	1	34	67	0.49
6	Waste due to negligence / sabotage	0	10	19	5	0	34	63	0.46
6	Improper application of tools/equipment	0	10	19	5	0	34	63	0.46
6	No organized storage	1	12	15	3	3	34	63	0.46
7	Delays in inter-site loans	2	10	17	3	2	34	61	0.44

Figure 4.11 b Project managers' opinions about material unavailability



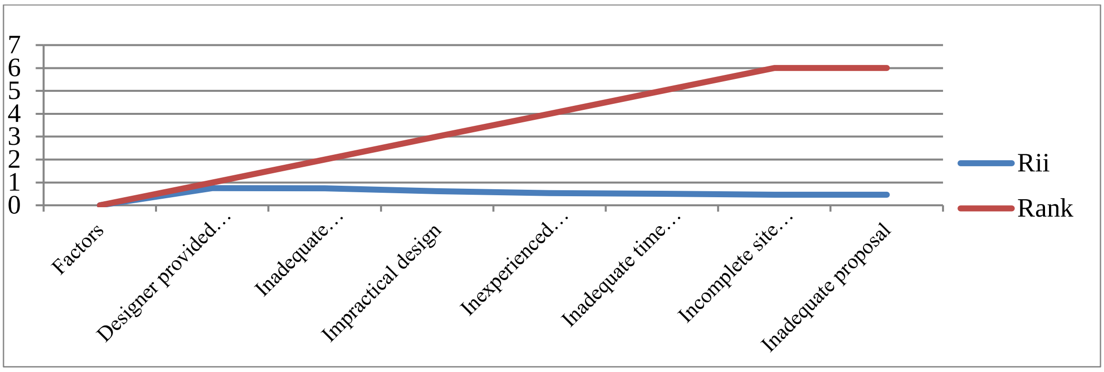
4.2.12 QUESTION 14 - INCOMPLETE DRAWINGS

The following Tables 4.12 a and 4.12 b and Figures 4.12 a and 4.12 b show the causes of incomplete drawings, such as architects/designers supplying incomplete detail, insufficient examination of accepted drawing, unrealistic designs, incompetent drafts people, insufficient site surveys, not enough time provided to drafters and insufficient proposals (Arslan & Kivrak 2008).

Table 4.12 RII for causes of incomplete drawings

Rank	Factors	Ranked Scores					Total #'s	Total scores	RII
		4	3	2	1	0			
1	Designer provided insufficient detail	9	18	6	0	1	34	102	0.75
2	Inadequate examination of approved drawing	9	18	5	1	1	34	101	0.74
3	Impractical design	4	14	12	3	`1	34	85	0.62
4	Inexperienced drafts people	0	13	13	8	0	34	73	0.53
5	Inadequate time provided to drafts people	2	8	13	11	0	34	69	0.50
6	Incomplete site survey	0	5	19	10	0	34	63	0.46
6	Inadequate proposal	3	3	15	12	1	34	63	0.46

Figure 4.12 RII for causes of incomplete drawings



Designers providing incomplete detail and not enough examination of accepted drawings were considered the main causes of incomplete drawings, with RII values of 0.75 and 0.74 and ranking as the first and second factors affecting productivity respectively. Designers providing insufficiently detailed drawings waste time, because of the need to wait for explanation; if this problem occurs before a project starts, this will lead to a chain effect that delays the entire project (Makulsawatudom, Emsley & Sinthawanarong 2004).

Furthermore, a tight schedule and lack of inspection by the examiner are the main causes of the insufficient examination of accepted drawings.

An example of impractical design, which was ranked third with a RII of 0.62, is tolerances that are too specific. Ranked fourth with a RII of 0.53, a main cause of inadequate drawings are incompetent drafters. Lack of work comprehension means that an incompetent drafter may generate drawings, which vary from the proposal, particularly with respect to detail (Kaming et al. 1998). Inadequate time provided to drafters with a RII of 0.50 is ranked fifth. Incomplete site surveys and inadequate proposals are ranked the sixth factor, with a RII of 0.46; they leave drafters with no choice but to count on their experience, acumen and working professionalism, which could be inadequate and lead to inaccurate drawings (Kaming et al. 1998).

4.2.13 QUESTION 15- LACK OF TOOLS AND EQUIPMENT

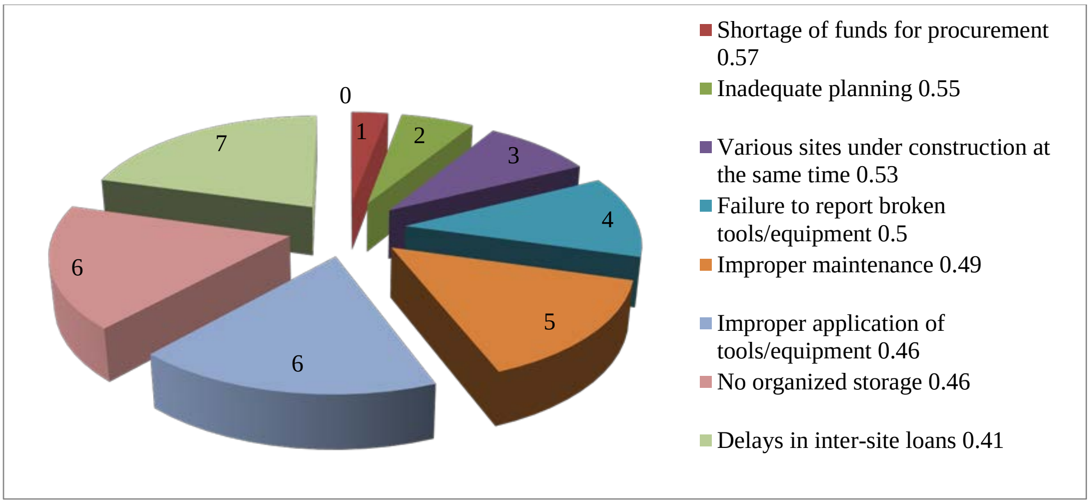
The following Table and Figure 4.13 show the factors that cause lack of tools and equipment, including improper maintenance, inadequate planning, shortage of funds for procurement, having various sites under construction at the same time, improper application of tools/equipment, failure to report broken devices/machinery, disorganized storage and interruption in inter-site loans.

Table 4.13 RII for factors of shortage of devices and machinery

Ranks	Aspects	Rated Scores					Total #'s	Total Scores	RII
		4	3	2	1	0			
1	Shortage of funds for procurement	2	14	10	8	0	34	78	0.57
2	Inadequate planning	3	9	14	8	0	34	75	0.55

3	Various sites under construction at the same time	0	13	13	8	0	34	73	0.53
4	Failure to report broken tools/equipment	2	8	13	11	0	34	69	0.50
5	Improper maintenance	1	3	24	6	0	34	67	0.49
6	Improper application of tools/equipment	0	5	19	10	0	34	63	0.46
6	No organized storage	3	3	15	12	1	34	63	0.46
7	Delays in inter-site loans	1	3	17	10	3	34	57	0.41

Figure 4.13 RII for factors of shortage of devices and machinery



Devices and machinery are essential for construction work, because without devices and machinery, no work will be achieved or done continuously or to an acceptable standard. For that reason, this aspect was rated fourth, with a RII of 0.50. Furthermore, the factor of improper application of tools/equipment is ranked sixth with a RII of 0.46 as a major influence on the building work rate. Examples of improper application of tools/equipment is using a damaged device at a site, using a measurement gauge to get rid of debris rather than using a debris hammer, which will damaged its efficiency, applying French wrench rather than using a hammer, which will cause loosening of its tuner; all these show that shortages of the right devices and machinery are an additional detracting aspect that influences the construction productivity in Australia.

Not using the right devices and machinery is the result of project administration inexperience with maintenance programs, which creates ineffective application of devices and machinery, use of outdated devices and machinery, lack of new components or project managers exaggerating the ability of machines, leading to inaccurate numbers of equipment on the site. However, to examine the factor of tools and equipment influencing construction productivity, the project managers were requested to rate normal reasons for shortages of devices and machinery from their building work knowledge; the conclusions are presented in Table 4.13 and Figure 4.13. The following factors (4.2.13.1 to 4.2.13.6) are explanations for factors affecting the productivity as follows:

4.2.13.1 SHORTAGE OF FUNDS FOR PROCUREMENT

The construction industry in Australia uses a large amount of money. Most of the Contractors and builders are in financial trouble so that they cannot handle daily business expenses, especially when clients delay their progress payments, leading to insufficient funds to cope with construction costs, aggravated for small contracting firms with financial problems (Harris & Mc Caffer 2001). Irregular cash instalments or progress payments to contractors on government projects is the main factor in contractors' bankruptcy. The primary financier of building/construction projects in Australia is the public sector (governments) because they own the majority of infrastructure (main roads, highways, public hospitals, educational institutions etc.

In addition, some major Australian banks support giant projects, including Westpac, Commonwealth Bank, National Australia Bank, ANZ and other banks. This might be referred to the main financing of the construction business, because the public administrations are taking on the entire responsibility for public construction works finance. At the moment, there is no assistance from personal bankers or shareholders in expenditure on government projects. Private contractors are not sharing financially in supporting public projects. This may be the usual agreement in force in the construction industry. Insufficient cash reserves were stressed by the survey participants as a moderate factor with a RII of 0.57 and ranked #1 in Table 4.13. It causes materials shortage; it is certain that the shortage of funds aspect is affecting the construction productivity and creating financial troubles, as it causes difficulties in obtaining materials, and also misuse of tools and equipment (Arditi & Mochtar 2000).

4.2.13.2 INADEQUATE PLANNING/PREPARATION

Regional builders/contractors are usually unsuccessful in creating a realistic and reasonable work program at the start of the planning stage. This failure indicates the lack of systematic site administration and insufficient builder/contractor experience in Australia's construction projects (Hendrickson 1998). Insufficient contractor preparations leading to shortage of detail causes delay in materials delivery, which is the responsibility of management (Goodrum & Haas 2002). Builders/contractors usually submit to the owner's work timetable on most projects, and this is usually a concise schedule that is rarely amended during construction work. Inadequate contract administration leads to insufficient contractor planning, which results in poor productivity (Hendrickson 1998), lack of finances for short- and long-term aims, an absence of specialisation and inadequate technical power. Inadequate planning is ranked number two in Table 4.13 with a RII of 0.55.

4.2.13.3 VARIOUS SITES UNDER CONSTRUCTION AT THE SAME TIME

With a RII of 0.53, this is rated third in Table 4.13. For example, if a number of Pumps or generators are required for projects at the same time; this may lead to not having enough pumps and generators. Hiring, borrowing or buying pumps and generators, at this stage, will relieve the problem (Arditi & Mochtar 2000).

4.2.13.4 FAILURE TO REPORT BROKEN EQUIPMENT

This has a RII of 0.50 and is ranked #4 (Table 4.13), while improper maintenance has a RII of 0.49 and is ranked #5 and improper application of tools and equipment has a RII of 0.46 and is ranked #6, as workers require a minimum number of devices and equipment to work adequately. If there is a shortage of equipment and/or devices, productivity will diminish. A shortage of suitable equipment could have a severe impact on productivity (Goodrum & Haas 2002), as without proper use of equipment, work will not progress or will be carried out to an unacceptable quality standard. On the other hand, it is understandable that these factors were rated four, five and six. Shortages of equipment are caused due to inexperienced management and inadequate maintenance programs that lead to ineffective use of equipment, use of out-of-date equipment, lack of reserve parts or a manager exaggerating the capacity of a piece of equipment, which can lead to not enough of the equipment being in working order (Goodrum & Haas 2002),

4.2.13.5 DISORGANIZED STORAGE

With a RII of 0.46 this is ranked #6 (Table 4.13). Disorganized materials storage and poor location have an average effect on productivity because workers need more time to find the required materials for their work, which causes delay, and this delay affects productivity.

4.2.13.6 DELAYS IN INTER-SITE LOANS

With a RII of 0.44, this is ranked #7 (Table 4.13); this is an insignificant value of construction productivity. However, if we can overcome this factor, productivity will improve as well.

4.3 ADMINISTRATION OF THE SURVEY

To evaluate the project managers' opinions about the significance of the aspects recognised during the pilot survey as having influence on the building productivity, 89 project managers in Queensland, Australia were mailed a well-planned survey requesting them to evaluate all of the aspects and their impact on the building work rate, applying a 0 to 4 Likert gauge. The survey included some directions and questions, and provided space for participants to jot down their thoughts. Each question was planned to be very exact, brief, easy, and reasonable.

4.4 RII CUT-OFF EXPLANATIONS

The basis for classifying the significance of the critical factors is the magnitude of the relative importance index (RII). The cut-off levels of RII varied between major factors, significant factors, moderate factors and factors that are not significant (low). The RII values based on $-1 < RII < +1$ and are classified similarly to the academic approach as follows:

- If the RII value is 0.800 or above it is considered a severe factor due to the significant impact upon the construction productivity (Muhwezi, Acai & Otim 2014).
- If the RII value is over 0.400 but less than 0.500, it is considered a moderate factor due to the moderate impact upon the construction productivity.
- If the RII value is less than 0.400, it is considered low to fairly low because it is not a significant factor due to the insignificant impact upon the construction productivity (Muhwezi, Acai & Otim 2014).

In addition, Hughes and Thorpe (2014) gave a useful approach not only considering the numerical value of the RII, but also the extent of responses of level 3 and 4 on a Likert scale. This approach will be used in this study to determine the level of importance of the factors and its significance in classifying the severity of the critical success factor. The factors subdivided into four categories according to their impact on the productivity such as 1) severe, 2) moderate, 3) low to fairly low and 4) nil response. An example of severe factors is the rework factor, which has a relative importance Indices (RII) of 0.917 (receiving 28 Likert scale rating of 4). The second factor which is considered as a severe factor is incompetent supervisors with a RII of 0.896 (receiving 26 Likert scale rating of 4).

These marks are likely to advocate that these responses should be considered in the range from a severe to a highly severe matter. These two tasks with their RII scores, could be treated as a potential and having a significant effect on construction productivity. Muhwezi, Acai and Otim (2014) stated that factors obtained RII less than 0.599 were insignificant in creating delay in any building tasks in Uganda.The above two scores for rework and incompetent supervisor are greater than 0.800; and therefore, it is considered as a severe to a highly severe factor. In the same fashion, the rest of the factors will be classified as moderate, low and fairly low.

4.5 THE DISCUSSION: RESEARCH FINDINGS

4.5.1 ELEMENTARY ASPECTS INFLUENCING BUILDING AND CONSTRUCTION PRODUCTIVITY

All 36 participants in the survey ranked the elementary aspects with regards to their anticipated influence on the building work rate on a Likert gauge of 1 (for no problem) to 4 (for a serious problem). Participants were instructed to use a 0 score if they did not have any opinion.

A relative importance index (RII) value was determined for every aspect, using the returned answers regarding this aspect. Then the RII was used to rate the aspects in a vertical form. The results are given for the 15 aspects treated as the main influences on building productivity.

4.5.2 PRINCIPAL ASPECTS INFLUENCING BUILDING PRODUCTIVITY

From the questionnaire survey sent to a number of Australian construction project managers and the results of the analysis of their responses, it was found that the most severe two aspects influencing the building productivity were redo/rework and unskilled/incompetent supervisors. These two aspects with RII values of 0.92 (collecting 28 Likert gauge rankings of 4 and five rankings of 3) and 0.90 (26 Likert gauge rankings of 4 and seven rankings of 3) respectively. These two aspects (redo/rework and incompetent supervisors) together with incomplete drawings incomplete drawing or unfinished designs, with a RII of 0.75 (13 Likert gauge rankings of 4 and 14 rankings of 3), these factors were classified as the aspects with the most extreme influence on the building productivity. The factors leading to unfinished designs are communicated in additional explanations in the following:

4.5.3 ASPECTS WITH A MODERATE TO SEVERE INFLUENCE ON BUILDING PRODUCTIVITY

The additional aspects thought to create a moderate to severe influence on the building productivity are listed below:

Fourth - work overload project with a RII of 0.60, and three Likert gauge rankings of 4 and 14 rankings of 3.
Fifth – poor communication with a RII of 0.58, and five Likert gauge rankings of 4 and five rankings of 3.
Sixth – shortage of construction materials (lack of material), with RII of 0.58 and four Likert gauge rankings of 4 and 8 rankings of 3.

4.5.4 FUNDAMENTAL ASPECTS WITH A MODERATE TO SEVERE INFLUENCE ON BUILDING WORK RATE/PRODUCTIVITY

Additional aspects receiving at least one rating of 4 on the Likert gauge are:

Seventh – poor site condition with RII of 0.51, and two Likert gauge ranking of 4 and six rankings of 3.

Equal seventh – A poor site layout, with a RII of 0.51, and two Likert gauge rankings of 4 and six rankings of 3

Equal seventh - overcrowding, with a RII of 0.51, and two Likert gauge rankings of 4 and six rankings of 3.

Equal seventh - inspection delay, with a RII of 0.51, and two Likert gauge rankings of 4 and six rankings of 3.

4.5.5 FURTHER ASPECTS WITH LESS TO A MODERATE INFLUENCE ON BUILDING PRODUCTIVITY

Eighth – absenteeism and worker turnover each had a RII of 0.50, and zero Likert gauge rankings of 4, seven rankings of 3, and 22 rankings of 2.

Ninth – Accident; tools/equipment breakdown; and lack of tools & equipment. Each of these three aspects had an RII of 0.47, and zero Likert gauge rankings of 4, three rankings of 3, and 25 rankings of 2.

4.5.6 ADDITIONAL ARGUMENT – ESSENTIAL ASPECTS IN BUILDING PRODUCTIVITY

In brief, the main two aspects with very high RII values are redo/rework and incompetent supervisors. This conclusion indicates that individual practical backgrounds (in relation to supervisors' and artisans' craft skills) are essential for profitable building, so the technical backgrounds of supervisors, artisans and project managers are significant in terms of regulating the building project budget and their knowledge can be passed onto the workers to be put into action. This could succeed with suitable classifications and workers' coordination with other groups on site. The project managers with well-recognised construction experience who responded to the questionnaire survey in this study (81% with over a decade in their jobs, with high experience in different projects of the building industry) stated that these factors will help to deliver successful projects.

Another aspect classified as having a vital impact on the building productivity is incomplete drawing or unfinished designs, with a RII of 0.75. Aspects with a moderate to severe influence on the building productivity are work overload, shortages of building components and lack of communication. The other aspects have a normal impact on the building productivity.

There are six aspects, which are rated as having a low impact on the construction productivity. These aspects are alteration requests, extra guidance time, unacceptable standards, intervention, negative weather circumstances, and changes in project managers or supervisors. The respondents included several of these factors in their rankings of the recorded 15 aspects.

4.5.7 SUBORDINATE ASPECTS OF UNFINISHED DESIGNS

During the time of the survey, the plan was to examine closely the three fundamental aspects: incomplete drawing (unfinished designs, shortages of building material and shortages of devices and machinery. All these aspects are treated as complex factors that have a severe influence on the construction/building productivity/work rate. As with the fundamental aspects, a few of the subordinate aspects were rated on the Likert gauge similarly to the fundamental aspects. This shows the importance of incomplete drawing & designs as the third highest rated aspect, meaning a very high effect on the construction productivity (its RII is 0.75). The fundamental aspects are discussed in depth in the next section, to demonstrate the procedures for analysing the fundamental tasks in this study.

It is notable from the rankings assigned that the fundamental aspects must be self-reliant on the rankings assigned; there were few participants who deliberated on their rankings enough for the aspect to be provisionally contingent on the ranking where they are classed as fundamental aspects. This matter might be considered when viewing the rankings and the related RII. Furthermore, the rankings of every subordinate aspect inside the framework of its relationship to the fundamental aspects will not be influenced by any consideration of whether the participants were ranking their full or limited impact on the construction productivity.

4.5.8 ADDITIONAL CONSIDERATIONS – SUBORDINATE ASPECTS REGARDING UNFINISHED DESIGNS

The main subordinate aspects regarding unfinished designs were incomplete details supplied by the drafters (RII = 0.75). These factor are thought to have severe impacts. An additional three aspects were unskilled designers, insufficient location scrutiny (these two aspects had a RII of 0.53) and insufficient time allowed to designers (RII = 0.50), all treated as having a moderate impact. Lastly, the aspect of unfinished proposals (RII = 0.46) was treated as having a low to average impact.

The conclusion is that the essential subordinate aspects relate to incomplete/unfinished designs, incomplete details supplied by drafters and insufficient investigation. These factors were evaluated by the participants in the survey as having a high influence on the fundamental aspects. Unrealistic drawings and designs had an average to severe impact on incomplete drawing/designs, but another four aspects were evaluated as having a reduced impact on this aspect.

4.5.9 RESPONDENT DEMOGRAPHIC INFORMATION

The introductory section of the survey determined simply the number of participants; all were men, almost 50 per cent over fifty years of age and none under thirty years of age. The least experience in the construction business was 6 years as a project manager (17%), but the rest, almost 42 per cent, had over 20 years of practical work in construction. Regarding technical qualifications, the majority had one qualification in the building industry, with almost 42 per cent having a tertiary degree and 39 per cent of bosses with a postgraduate degree. Regarding the length of stay with their current employers, almost 36 per cent had spent more than ten years with their most recent employers. Regarding the type of job, 78 per cent were employed by general contractors and three per cent by subcontractors; the rest were not identified.

The surveyed project managers were generally content with their employers, their assistance, and their employment circumstances.

The project manager bosses had a wide scope in all types of building and construction projects and their present work supported this. Seventy-two per cent was residential and non-residential construction work. Other companies were handling 75 per cent civil work.

4.5.10 ANALYSIS OF THE OUTCOME ISSUES

In the present study, a few of the aspects ranked by the participants in the questionnaire with regards to their influence on the building work rate were recognised and rated relative to their RII as seen in Table 4.10(a) (the fundamental aspects have an average or severe impact on the construction productivity) and Table 4.12 (the subordinate aspects with respect to the fundamental aspects of incomplete drawings).

In Table 4.10(a), redo/rework is rated as the main aspect influencing the construction productivity, with a RII of 0.92. Rationally, if rework is needed, extra expenses (time and cost) will be required to finish the project. Redo/rework may be related to a few of the additional fundamental aspects influencing the productivity, for example, supervisor confidence, incomplete drawings, and extra activities/overburdening.

The redo/rework situation could be negatively affecting the project direction, e.g., concerning the total expenses (costs, time, and shareholder). The effects of redo/rework on the project administration activity mostly include an extra period of time for rework; an extra expense for covering rework circumstances; extra building components for rework and consequent ineffective management; and more workers needed for rework and connected expansion of management of workers. The reasons for rework might involve architectural alterations, structural mistakes or oversights, contractor replacements, owner mistakes or oversights, owner replacement and shipment mistakes (Hwang et al. 2009). Drawing replacements are associated with incomplete drawings, where it was the third rated aspect influencing the productivity in this research. The only way to reduce the quantity of rework is to involve the artisans in the project activities, specifically concerning the detailed features (Megha & Rajiv

2013; Rojas & Aramvareekul 2003 b).

Supervisor ability was rated second because of its impact on the construction productivity with a RII of 0.896; this means that the aspect has a strong impact on the productivity. The results agree with the conclusion of the researcher, who has noted that very skilled supervisors develop the project administration, communication of the project activities, and the project's finishing or delivering time, expenses, and standard. It is speculated that redo/rework and supervisor capability are affiliated.

Incomplete drawings were rated third among the fundamental aspects (including the standard changes through carrying out the project), so with a RII of 0.75 it is thought to have a severe effect on the construction productivity. The study states here that the RII for these aspects is probably due to the drafters, insufficient investigations of the finished designs, supplying this conclusion from data on a few subordinate (or contributing) aspects, for example, lacking information and unrealistic drawings (refer to Table 4.3). Without finished designs, it is hard for competent construction management firms to assemble the right specifications and lists of materials for the targeted project, leading to expenses exceeding the project budget because of underestimation and re-measurement. Designs are in addition critical in the project administration procedures, for example, preparations, organizing and ruling. If designs are unfinished, it will be impossible to complete any work. That aspect could be interpreted as an alteration in the spec and in the design that needs extra time for modifications of assets and workforce. The number of alterations could change the workers' attitudes and mood.

The fourth rated aspect, work overload, has a RII of 0.604 and as a result this aspect looks like a more ineffective influence on the construction productivity than the first three aspects, although it could create severe complications. On the other hand, if the workers work a full week (seven days per week) without any break, this will have a serious impact on their productivity, while working a few extra hours per week as limited overtime will not create any serious problem and will have a moderate influence on productivity.

The fifth-rated fundamental aspect, shortages of building materials, has a RII of 0.583; accordingly, it has a similar rating to work overload. A number of the project managers considered it an effective aspect concerning construction productivity because building components are essential for building activities. Further, project works are normally interdependent; lack of building components for a specific project could influence other project. Time interruptions because of lack of building materials can influence building project plans, and then productivity, expenses and project schedule.

The subordinate aspects leading to this factor include the lack of cash reserves (this can happen in any building project when the project has a limited budget), insufficient plans, too much office work, inappropriate building component management with regards to specs, variations in building components, misuse because of carelessness/damage, lack of materials, inefficient transfer of building components to the location, transport problems and building component mismanagement on site.

Communication has a very similar rating to work overburdening and shortages of materials, with a RII of 0.58, and so is treated as having an average influence on the construction productivity. Better communication plays an important part in project administration. As mentioned above, poor communication between the working teams themselves and the administration or management can lead to ineffective activities on the work site (Chancellor 2015; Makulsawatudom, Emsley & Sinthawanarong 2004).

The other fundamental aspects had RII varying from 0.465 to 0.514, and are accordingly treated as having a manageable impact on the construction productivity. They are unsuitable location environments, unsuitable location design/planning and congestion (each rated seventh with a RII of 0.514); examination interruption (rated tenth with a RII of 0.507); deserting the workplace and artisan turnout (each rated eleventh with a RII of 0.500); and injury, devices failure, and shortages of devices and machinery (each rated thirteenth with a RII of 0.465).

Absence from the workplace (rated 11th in the questionnaire) has an influence on project activities and could cause a severe problem to any project that needs people who are professional and expert. It could cause delay in examinations or interruptions to near-completed projects that then interrupt the starting of fresh projects. Likewise, worker turnout (rated 11th) has a limited impact on the construction productivity. Nevertheless, it is clear that good worker turnout will take place in the following two conditions: resilient markets (when it is very hard to find labourers, artisans or staff to do the job), and when the companies or the contractors have few work agreements and are required to lay off their workers and staff to stay in the market.

Accidents on construction sites is considered likely to happen; therefore, this aspect represents a high risk on the workers productivity/work rate, and is rated 13th on the questionnaire. Minor accidents could affect the project schedule, but with major accidents such as deaths, the project will stop totally. Nevertheless, a combination of workplace security regulations and permanent instructions about workplace security in Australia can minimise the risk of an industrial accident.

The shortages of devices and machinery were also rated 13th in the questionnaire; this aspect was rated higher in a previous questionnaire (Chancellor 2015; Makulsawatudom, Emsley & Sinthawanarong 2004) where it was rated fourth. Therefore, because of the complication of this aspect, participants were requested to rank the subordinate aspects associated with this aspect. Those aspects were lack of cash reserves for acquisitions, insufficient preparation (this can lead to interruption of the work), more than one location being under construction in the same time (this will increase the need for devices and machinery), declining to repair dilapidated devices and machinery (which will create a lack), inappropriate maintenance programs, inaccurate use of equipment, disorganised storage, and delays to paper work. This aspect is treated as a significant factor because without appropriate usage of the devices and machinery, the project will stagnate; there will be no progress and unacceptable work.

4.6 CONCLUSION

This section of the study explains the characteristics of the participants and discusses the outcome of the survey carried out to answer the research questionnaire. As discussed in Chapter 3, the investigation included project managers (PMs) involved in construction projects in Queensland and Australia nationwide.

The project managers were supplied with the questionnaire and challenged with questions concentrating on their background and practices and limited to a specific project. This data was collected from parties directly involved with construction project management. The questionnaire was prepared and planned to gather information on the actual aspects of construction detracting from favourable outcomes and causing delays.

This investigation was done in two steps, as follows:

1. Step number one was the collection of data, which included reviewing related literature and gathering data through site visits for the pilot questionnaire and then the actual pilot questionnaire and discussions with different ranks of project managers.
2. Step number two focused on data study of the information collected during the census examination and identifying the most relevant factors causing construction productivity problems; this guided the development of the main survey that was delivered to a number of project managers in different projects with different capacities around Australia.

The questionnaire carried both the instructions and the questions to the participants and provided space for participants to write any comments. There were some considerations for both the subject content and the wording of each question in terms of shared vocabulary and clarity. Each question was stated in such a way as to be as exact, brief, clear and understandable as possible.

The survey consisted of two essential sections. The first section was an introduction in order to clarify the concept and the aim of the questionnaire (cover letter, consent form and the study at a glance). The second part, which was the main questionnaire, included questions 1 to 16.

CHAPTER 5

A MODIFIED DELPHI METHODOLOGY (QUASI DELPHI SURVEYS) AND TESTING THE RESULTS AGAINST EXPERTS

5.1 INTRODUCTION

The Delphi method is a well-known technique and its target is to create consensus. It was used here to collect opinions from a team of experts from the construction industry through a written questionnaire. The Delphi technique is a 'comparably strong selected team communication methods, in a matter, where on that normally uncertain and insufficient background is accessible, are assessed through an experts' (Häder & Häder 1995).

Description of Delphi method: the Delphi technique consists of two or three rounds and the data collected in the first round is summarized and used for discussion in the next round. The data obtained from the second or third rounds form the consensus required. Delphi surveys can be built to recognise and preference the procedures' targets. Because the Delphi approach involves scrutiny over two or more rounds, the outcome of the prior round acts as feedback (Enshassi et al. 2014; Cuhls, Blind & Grupp (eds) 1998; Wechsler 1978). Enshassi et al. (2007) describes an 'Accepted Delphi Technique' in the following way: 'It is a survey where it is steered by a monitor team, consisting of a number of rounds of a team of experience, and they are anonymous to each other. At the end of each survey round, a standard feedback about the statistical group assessment calculated from the median and quartiles of single prognoses is given and if possible, the arguments and counter argument of the extreme answers are fed back'.

5.1.1 CHARACTERISTICS OF THE DELPHI APPROACH

The characteristics of the technique are specified as follows:

The Delphi method is well adapted as a channel and procedure for consent by applying a series of surveys to gather information from a team in relation to chosen issues also is a method used to estimate the likelihood and outcome of future events.

A group of experts exchange views, and each independently gives estimates and assumptions to a facilitator who reviews the data and issues a summary report (Chan et al. 2010; Young & Jamieson 2001). Delphi is a multiple iteration method.

The Delphi technique concentrates on the intellectual procedures associated with communication, rather than numerical styles, and it include creating judgements in the face of ambiguity. The expert team that participates in a Delphi survey only gives an estimate. The selected experts who participate in the survey should be highly experienced with intensive knowledge of the construction industry to give competent assessments. The Delphi technique relies on a panel of experts. This panel may be your project team, including the customer, or other experts from within your organisation or industry. An expert is, any individual with relevant knowledge and experience of a particular topic (Cantrill, Sibbald & Buetow 1996). Also, the method stresses the psychological processes involved in communication, rather than mathematical models and it involves making judgements in the face of uncertainty. The experts' team involved in the Delphi survey only give an estimate (Outherd 2001; Cabaniss 2002).

5.1.2 WHEN IS DELPHI APPROPRIATE FOR USE?

The Delphi technique is appropriate for judgment focusing on required evaluation or expected guidance (Gamon 1991). The technique helps to collect the ideas of a large team of experts and in an area where there is not enough proof about the issues, and where experts can express their real ideas freely (JRC European Commission 2005–2007).

A second method of identifying the Delphi method is that it is a technique applied to assess the probability and the effects of a forthcoming occurrence. A team of experts swap aspects and every member of the team present their assessment and expectation to a coordinator, who inspects the information and prepares a conclusion summary (Ameyaw et al. 2016; Cantrill, Sibbald & Buetow 1996).

5.1.3 WHO USES THIS TECHNIQUE?

Most users of this technique are researchers from tertiary institutions including

postgraduate students, industrial and commercial firms and organizations, specifically their planning divisions. Regarding the nationwide Delphi technique, the main population is normally identified as everybody who is concerned about information regarding the forthcoming occurrence; in addition, other firms, organizations, ministries, journalists, and teachers can be involved. This formalized and traceable method has credibility with policymakers.

5.1.4 WHO ARE THE PARTICIPANTS IN DELPHI SURVEYS?

These are the stakeholders who are participating in decision-making, constituting the panel of expert respondents from the construction industry, business, government, tertiary institutions, researchers, associations and other persons who are expert and competence in the area of the matter. The expression ‘expert’ is applied here in a broad connotation.

Selection of expert panel: One of the most important considerations when carrying out a Delphi study is the identification and selection of potential members to constitute the panel of experts (Ludwing 2001; Stone & Busby 1996).

The selection of members or panellists is important because the validity of the study is directly related to this selection process. In this Delphi survey, the candidate tried to identify panellists who meet all the following selection criteria:

(1) Having sufficient working experience or knowledge in the construction industry.
(2) Working with relevant organizations in the construction industry.
(3) Having sound knowledge and understanding of strategic management.

Finally, 20 experts meeting the selection requirements agreed to participate in the Delphi survey. A list of the panel groups consists of five members each and their affiliations are Academia, Consulting engineers**,** Public works departments (government) and Construction organizations (contractors)

The selected experts represent a wide spectrum of construction professionals and provide a balanced view for the Delphi study. Most of the experts have sufficient experience and expertise in construction management; the respondent classifications by years working in construction industry. All the experts have sound knowledge in the strategic management. Furthermore, some of the experts hold management positions in their organizations and the sufficient working experience, sound knowledge in strategic management, and relevant organizations of the selected experts ensure the validity of this Delphi research study.

5.1.5 DELPHI PROCESS ORGANIZATION

The Delphi process in this research has been organized in the following way: a steering committee formed a management team with sufficient skills and capacities for the process. The expert panel was selected. The form of the questionnaire was decided; an electronic or paper one? The follow-up was organized by phone or email, also printing of the questionnaire and envelopes for posting it.

5.1.6 QUESTIONNAIRE DESIGN

The Delphi method used by the author consisted of two rounds in sequence. Each Delphi round had its objective and it was relevant to the next Delphi round. The questions were driven by each round’s objectives and were written clearly, defined well and easy for the panel members to answer. The question for the participant panel members was what skills, behaviour, thinking, knowledge, understanding and attitudes are necessary for the innovative entrepreneur?

5.1.7 SELECTING THE PANEL OF EXPERTS

The Delphi expert panel is a group-decision mechanism that mandates a group of experts with deep experience and understanding of the field of the subject, such as construction productivity. Therefore, the selection of the expert project manager team for the construction industry was one of the most delicate procedures in the whole Delphi process. The number of expert panel team members should be between ten and twenty at most, otherwise the Delphi survey will be considered a standard survey (Outherd 2001; Cabaniss 2002).

In the second round survey of this research, five academics were involved in answering the survey questions from their practical experience in the fields of building/construction and tertiary teaching. They described the teaching and learning used to develop engineers' and project managers' skills to develop different ways to improve productivity in the construction industry.

5.1.8 DATA ANALYSIS

All the information from the project managers' responses was statistically evaluated to quantify qualitative matters and make qualitative evaluations by applying the statistical program for social science (SPSS) program, and the analysis is presented in a statistical way. But in a Delphi survey, the number of respondents in each round of the survey is limited to between ten and twenty members only; this would make it hard and costly to use SPSS. Therefore, the statistical calculation was carried out by hard calculations.

5.2 RESEARCH STRATEGY EXPLANATIONS

The problem of construction productivity in the building business is a worldwide problem and the building industry in Australia is not a special case. The target is all groups that participate in building projects, such as proprietors, contracting firms, architects, stakeholders, and consulting firms, with both government and individual parties, in order to finish the project successfully on time, with specific budgets and with the best features and ethical conduct. One of two critical aspects, which help the tasks parties realise the gaols as planned or some other aspects which obstacles or delay the project completion, usually affects construction tasks.

The goal of this study was to look for construction productivity success factors, which can assist all groups, which participate, in construction projects to reach the goal with higher efficiency. The research had many steps and the first step was to review the literature and tackle a number of factors affecting construction productivity, and then have them ranked by a group of selected project managers.

The study used an inclusive pilot survey and reviewed this to prepare and distribute a questionnaire scrutiny to examine the main critical aspects; thereby to obtain the consent of experts to apply the Delphi technique to rate the main critical aspects for Australian building project productivity. A high-quality questionnaire was delivered to a number of highly regarded expert project managers to examine all the factors.

All the data was collected and evaluated by statistical methods, using either SPSS or statistical hard calculations to classify the most important elements affecting productivity, and this is the method that has been used in this research. A relative importance index (RII) has been applied to decide the relative importance of assorted aspects influencing the building work rate. Finally, a Delphi approach, applying the expertise of a group of project managers, was adopted to recognise the essential critical aspects to improve Australian construction productivity.

Furthermore, the investigation of methodologies in Chapter 3 (research methodology and questionnaire design) and Chapter 4 (results and analysis), and in this chapter (Chapter 5), were validated using the consensus-forming Delphi method. This approach was chosen because it supplies the research with a soft and resilient device to collect, to examine, and to determine the information. This chapter explains the Delphi approach, applying the expert group to rating the most significant main critical aspects for Australian building productivity. The main critical aspects identified in Chapter 4 are shown in Table 5.1.

5.3 THE DELPHI METHODOLOGY USED

The Delphi questionnaire survey was initially submitted to the Human Research Ethics Committee at the University of Southern Queensland (USQ) for review, discussion and approval, then it was piloted with experienced academic staff at USQ and with a group of well-qualified building project managers. The main intention of piloting was to test the questionnaire’s clarity and ability to be answered by the chosen project managers in the Delphi group (Miller 2006; Hill & Fowles 1975).

A purposely selected group of experts was chosen to undertake the questionnaire survey. Special consideration was given in selecting the Delhi panel members who would respond to the questionnaire survey, such as their characteristics, the group background, the survey topic under research and professional experience (JRC European Commission 2005–2007).

The selected expert panel members for this survey were from different professions as follows:

- Academia
- Consulting engineers
- Public works departments (government)
- Construction organizations (contractors)

The selected Delphi expert panel members were contacted by email and telephone to get their approval to participate in the research survey and to decide their eligibility to participate in the survey:

- Had the role of representative of the stakeholder (owners, contractors or engineers).
- Having sufficient working experience or knowledge in the construction industry.
- Working in relevant organizations in the construction industry.
- Having sound knowledge and understanding of strategic management
- Analysing data from the panel.
- Co-operating with the other members of the experts panel.
- Participated with new ideas in the process.
- Were available for contacting personally for any clarifications.
- Experienced in contract management for over 15 to 20 years in the building business.
- Ready to participate in the Delphi's two- or three-round process.
- Analysing the new input and returning to the panel members the distribution of the responses.

Initially, the Delphi questionnaire focused on a team of twenty experts who were chosen as above to represent the stakeholders of the construction industry in Australia. The participants in the Delphi panel presented with a sheet of paper called ‘the study at a glance’, which contained an explanation of the principal goal of this study, the study method, and the survey questions to be asked.

The questionnaire was planned to apply one round of the survey preceded by a standard full questionnaire. In the Delphi questionnaire, the participants were requested to deal with 15 aspects for avoiding construction productivity problems. An explanatory sheet was attached with the critical success factors to explain the reasons for the critical success factor selection.

The expert panel was asked, based upon their experience, to rate the aspects in consideration of the significance of their effects on the procedure and their frequency of occurrence. The expert panel was asked to add any additional factors that they felt should be added to the questionnaire list. The questionnaire was prepared in the English language. An explanatory sheet was attached and any unclear question was explained directly or by other communication method such as Australia Post, telephone and email.

The Delphi second-round questionnaire ended with four open-ended questions to ask the participants about their opinions in detail for additional suggestions about the following:

- The most significant changes that they or their company could make to improve construction productivity?
- Any additional factors that they consider significantly affect the work rate in the building business?
- Any consideration that the level of industry productivity has changed over the last five years and if so, how and why?
- What are the most significant changes that governments in Australia could

make to improve construction productivity?

The participants in the survey were requested to rate the impact of every success aspect and its frequency of occurrence based on an ascending numerical order of importance from 0, indicating the minimum effect or less critical, to 10, indicating the most important or the maximum effect. Personal information was considered in order to identify each participant such as position or title, company or organization name, years of experience and achievement.

The questionnaires for round one and round two were sent by email, fax and Australia Post to the participants at their addresses at the same time, followed by telephone calls or emails for follow-up every two weeks from the initial sending date and repeated three times, then discarding participants who had still not responded.

Fifteen out of twenty experts replied to the questionnaire. Those participants were from academia, consulting firms, public works, and construction and contracting firms:

- Academic staff specialists in building project administration from the University of Southern Queensland (five participants)
- Consulting firms with local and international experience (five participants)
- Public works department (five participants)
- Construction and contracting firms (five participants)

The questionnaire was completed successfully, with a sufficient number of participants having responded, and each individual of the groups received a copy of the questionnaire analysis as promised.

The responses received from the participants' first round and second round were processed. The results from the two rounds were almost identical, so it was decided that a third round of the questionnaire would not show any significant changes in the Delphi panel's opinion and therefore a third questionnaire was not necessary.

Delphi methods need enough time in order to gather data to arrive at a general agreement, and sometimes in some circumstances it can reach three iterations (Ameyaw et al. 2016; Brooks 1997; Worthen & Sandlers 1987). The Delphi approach may be repeated until an agreement is reached as to the required results, where the values of both the moderate and the mean ratings are identical. Therefore, the Delphi method was considered and confirmed that it was satisfactory at that stage. The numbers of experts used were limited to twenty experts initially asked, of whom 15 responded. Two issues were considered and used to remove some experts from the survey: i) no response; ii) inconsistency in ranking.

5.4 DATA TABULATION OF DELPHI SURVEY RESPONSES

The data collected from the experts' replies to the Delphi questionnaire was classified and usually evaluated by applying SPSS if the number of respondents was high, but in the second round of the Delphi survey standard statistical calculations for moderate ratings and the arrangement of significance for every aspect were used, as indicated in Table 5.2. Experts are identified by indexing characters for confidentiality.

5.5 CALCULATING THE RELATIVE IMPORTANCE INDEX (RII) FOR THE EXPERTS' SURVEY RESPONSES

In the Delphi second round expert survey, the participants were requested to arrange the critical aspects influencing the building work rate on a 0 to 10 Likert gauge with respect to the rate of significance according to the methods seen to impact on the building work rate (the selected scale of 0 to 10 was chosen for accuracy and is better than a scale of 0 to 4). The principles appointed to each were as the following:

0 – zero assessment (excluded from the calculations)
1 to 2 – zero influence
3 to 4 – minimum influence
5 to 7 – severe influences
8 to 10 – great severe influence

It should be noted that the values appointed to the replies (0 to 10) do not mean that the periods between these values are alike, nor do they means exact/perfect numbers (Naoum 2016; Naoum 1998).

A relative importance index (RII) was used to preference the severity of the aspects (Tengan et al. 2014; Ugwu & Haupt 2007, Iyer & Jha 2005).

$$RII = (\sum_{r=1}^{r=10} r * n_r) / (10 * N)$$

Where:

r: represents the ranking on a Likert gauge (0 to 10) regarding its influence on the building productivity for a specific aspect influencing the building work rate

n_r: represents the responses of the participants supplying a specific Likert gauge rating r

N: represents the comprehensive responses of the participants to a specific inquiry (the figure was 15).

The RII for the Delphi survey was calculated by dividing the scaled load by 10, with invalid inquiries given a score of zero.

Table 5.1 shows the critical success factors as they were ranked by the initial survey. These rankings are should in Table 4.10 (a).

Table 5.1 Critical success factors (ranked)

Critical success factors	
Rank	Factors
1	Rework
2	Incompetent supervisor
3	Incomplete drawing
4	Work overload
5	Poor communication
6	Lack of material
7	Poor site conditions
7	A poor site layout
7	Overcrowding

7	Inspection delay
8	Absenteeism
8	Worker turnover
9	Accident/Tools/equip
9	Breakdown
9	Lack of tools & equipment

Table 5.2 Delphi survey responses analysis (the impact on the process).

FACTORS	RANKING TO PARTICIPANTS																				Average mean	Median rank	Mode	Relative importance index- RII
	Academic staff from USQ					Consulting engineering Firms					Public works departments					Construction and contracting firms								
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T				
Rework	9	8	10	5	7	6	3	7	6	x	4	10	6	x	x	10	3	9	x	x	6.8	7	6	0.68
Incompetent supervisor	9	8	10	8	9	9	8	9	2	x	8	2	4	x	x	10	7	8	x	x	7.4	8	8	0.74
Incomplete drawing	9	6	10	2	8	7	8	7	3	x	8	1	7	x	x	8	8	6	x	x	6.5	7	8	0.65
Work overload	4	7	6	2	7	5	1	3	3	x	8	10	5	x	x	10	3	7	x	x	5.4	6	7	0.54
Poor communication	8	8	10	7	8	7	3	8	9	x	8	10	7	x	x	10	2	7	x	x	7.4	8	8	0.74
Lack of material	8	4	10	8	8	4	2	10	4	x	6	10	5	x	x	3	5	7	x	x	6.2	7	8	0.62
Poor site conditions	4	6	9	4	7	3	2	3	3	x	5	10	4	x	x	6	1	7	x	x	4.9	4	4	0.49
A poor site layout	6	7	9	4	6	4	1	3	5	x	8	10	4	x	x	6	1	8	x	x	5.4	6	6	0.54
Overcrowding	7	4	9	3	6	2	1	5	3	x	8	10	6	x	x	10	1	7	x	x	5.4	6	6	0.54
Inspection delay	6	3	5	1	6	4	1	5	5	x	7	8	5	x	x	5	1	6	x	x	4.5	5	5	0.45
Absenteeism	5	5	10	3	5	3	10	1	3	x	7	10	4	x	x	5	1	7	x	x	5.2	5	5	0.52
Worker turnover	4	7	10	3	6	2	9	5	5	x	9	10	4	x	x	3	1	7	x	x	5.6	5	5	0.56
Accident	5	7	10	1	7	4	2	10	2	x	6	6	4	x	x	1	1	6	x	x	4.8	6	6	0.48
Breakdown	4	3	10	4	6	8	2	2	2	x	8	10	4	x	x	4	2	6	x	x	5.0	4	4	0.50
Lack of tools & equipment	4	3	10	4	5	6	3	7	3	x	8	10	5	x	x	5	3	4	x	x	5.3	5	3	0.53

Table 5.3 Delphi survey responses analysis (frequency of occurrence).

FACTORS	RANKING TO PARTICIPANTS																				Average mean	Median rank	Important order /Mode	Relative importance index- RII
	Academic staff from USQ					Consulting engineering firms					Public works departments					Construction and contracting firms,								
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T				
Rework	9	2	7	2	5	7	6	7	7	x	6	2	6	x	x	10	1	4	x	x	5.4	6	7	0.54
Incompetent supervisor	4	3	6	4	2	9	8	3	2	x	2	2	3	x	x	5	4	3	x	x	4.0	3	3	0.40
Incomplete drawing	4	6	4	2	2	10	8	7	2	x	3	1	5	x	x	10	7	2	x	x	4.8	4	2	0.48
Work overload	3	2	5	1	4	5	1	3	7	x	1	1	5	x	x	2	2	2	x	x	2.9	2	2	0.29
Poor communication	6	4	5	3	3	7	3	5	6	x	2	1	6	x	x	6	2	3	x	x	4.1	5	6	0.41
Lack of material	4	6	5	1	4	4	2	9	7	x	4	1	5	x	x	3	2	2	x	x	3.9	4	4	0.39
Poor site conditions	3	3	5	2	2	2	2	3	2	x	5	1	4	x	x	2	1	3	x	x	2.6	2	2	0.26
A poor site layout	3	3	3	3	2	3	1	5	5	x	6	3	4	x	x	3	1	4	x	x	3.2	3	3	0.32
Overcrowding	4	3	2	2	3	0	1	5	5	x	1	3	5	x	x	2	1	2	x	x	2.6	2	2	0.26
Inspection delay	3	2	1	1	0	1	1	5	2	x	2	2	5	x	x	3	2	4	x	x	2.4	2	2	0.24
Absenteeism	2	2	1	2	2	3	10	1	2	x	1	2	4	x	x	4	2	4	x	x	2.8	2	2	0.28
Worker turnover	4	4	2	2	1	4	9	2	5	x	3	2	4	x	x	1	3	3	x	x	3.2	3	4	0.32
Accident	3	2	3	1	1	3	2	5	1	x	2	2	4	x	x	1	2	3	x	x	2.3	2	2	0.23
Breakdown	3	2	2	1	1	6	2	3	2	x	2	2	4	x	x	2	4	1	x	x	2.4	2	2	0.24
Lack of tools & equipment	3	3	3	1	1	3	3	7	3	x	2	2	5	x	x	1	4	2	x	x	2.8	3	3	0.28

Table 5.4 Relative importance index calculations for Delphi responses (Rankings)

FACTORS	Ranking scores											Total responses	Total Score	RII	RANKS
	0	1	2	3	4	5	6	7	8	9	10				
Rework	0	0	0	2	1	1	3	2	1	2	3	15	103	0.68	2
Incompetent supervisor	0	0	2	0	1	0	0	1	5	4	2	15	111	0.74	1
Incomplete drawing	0	1	1	1	0	0	2	3	5	1	1	15	98	0.65	3
Work overload	0	1	1	3	1	2	1	3	1	0	2	15	81	0.54	6
Poor communication	0	0	1	1	0	0	0	4	5	1	3	15	112	0.74	1
Lack of material	0	0	1	1	3	2	1	1	3	0	3	15	94	0.62	4
Poor site conditions	0	1	1	3	3	1	2	2	0	1	1	15	74	0.49	10
A poor site layout	0	2	0	1	3	1	3	1	2	1	1	15	82	0.54	6
Overcrowding	0	2	1	2	1	1	2	2	1	1	2	15	82	0.54	6
Inspection delay	0	3	0	1	1	5	3	1	1	0	0	15	68	0.45	12
Absenteeism	0	2	0	3	1	4	0	2	0	0	3	15	79	0.52	8
Worker turnover	0	1	1	2	2	2	1	2	0	2	2	15	85	0.56	5
Accident	0	3	2	0	2	1	3	2	0	0	2	15	72	0.48	11
Breakdown	0	0	4	1	4	0	2	0	2	0	2	15	75	0.50	9
Lack of tools & equipment	0	0	0	4	3	3	1	1	1	0	2	15	80	0.53	7

Table 5.5 RII calculations for Delphi responses (frequency of occurrence)

FACTORS	Ranking scores											Total # of responses	Total scores	RII	Ranks
	0	1	2	3	4	5	6	7	8	9	10				
Rework	0	1	3	0	1	1	3	4	0	1	1	15	81	0.54	1
Incompetent supervisor	0	0	4	4	3	1	1	0	1	1	0	15	60	0.40	4
Incomplete drawing	0	1	4	1	2	1	1	2	1	0	2	15	73	0.48	2
Work overload	0	4	4	2	1	3	0	1	0	0	0	15	44	0.29	7
Poor communication	0	1	2	4	1	2	4	1	0	0	0	15	62	0.41	3
Lack of material	0	2	3	1	4	2	1	1	0	1	0	15	59	0.39	5
Poor site conditions	0	2	6	4	1	2	0	0	0	0	0	15	40	0.26	10
A poor site layout	0	2	1	7	2	2	1	0	0	0	0	15	49	0.32	6
Overcrowding	1	3	4	3	1	3	0	0	0	0	0	15	39	0.26	10
Inspection delay	1	4	5	2	1	2	0	0	0	0	0	15	34	0.22	13
Absenteeism	0	3	7	1	3	0	0	0	0	0	1	15	42	0.28	8
Worker turnover	0	2	4	3	4	1	0	0	0	1	0	15	49	0.32	6
Accident	0	4	5	4	1	1	0	0	0	0	0	15	35	0.23	12
Breakdown	0	3	7	2	2	0	1	0	0	0	0	15	37	0.24	11
Lack of tools & equipment	0	3	3	6	1	1	0	1	0	0	0	15	43	0.28	8

Table 5.6 Explanations for main success factors in Tables 5.2 to 5.5

Rework: Correcting of defective, failed, or non-conforming items, during or after the inspection. Rework includes all follow-on efforts such as disassembly, repair, replacement & reassembly.
Incompetent supervisor: A person who is not possessing the necessary ability, skill, etc. to do or carry out a project; incapable to make a decision.
Incomplete drawing: Is a drawing without insufficient details, dimensions, misprinted and not enough specifications. Unless the drawing is finished the specialist quantity surveyor cannot create a perfect spec and a list of material for the undergoing building agreement project, and it will cause over budget expenses due to under-assessment and re-calculation.
Lack of material: The materials play a very important part and are needed for any building projects. Furthermore, any construction project procedures are normally related, and if there is a lack of materials needed for a specific goal, this shortage of material will affect severely the rest of the project procedure.
Work overload: Extended workweek schedules are used from time to time to replace a larger team of workers, in order to accelerate the construction activities or to bring an extra worker to a trades-shortage location. If workers work a full week (seven days per week) without any break, it will have a serious impact on their work rate, while working a few extra hours per week as limited overtime will not create any serious problem and will have a moderate influence on productivity.
Poor communication: This has a similar rate to work overburdening and shortages of material, with a RII of 0.576, and so treated as having an average influence on the building work rate. Communication plays a very important part in any project administration. As mentioned, poor communication between the working teams themselves and the administration or the management could lead to ineffective activities on the work site (Makulsawatudom et al. 2004).
Poor site conditions: The effects of poor site conditions vary from site to site and may lead to working difficulties and unsafe working conditions. Consequently, accidents may occur, which cause delays. Poor site preparation is one of the causes of an unsafe working condition and it affects the productivity on site.

A poor site layout: Poor site layout creates building component delivery interruption and it is the responsibility of the project administration. A crucial project has a significant impact on construction cost, productivity, and safety.
Overcrowding: Overcrowding is the increase of all labour types within a given construction work area. Overcrowding uses an increase of all trades without specifying which crafts are within the work area.
Inspection delay: Inspection delay may delay job progress, and contributes to delays in work activities and for jobs on the critical path.
Absenteeism: Absence from the workplace (rated 11th in the questionnaire) has an influence on the project activities and it could cause a severe delay to any project that needs professional and expert people. It could cause delay in examinations or interruptions to completed projects that consecutively interrupt starting of fresh projects and it has a negative influence on construction productivity.
Worker turnover: Labour turnout (rated 11th) has a limited impact on the building work rate. Nevertheless, it is clear that labour turnout will happen in the following two conditions: resilient markets (when very hard to find labourers, artisan or staff) and when the companies or contractors have few work agreements and are required to lay off their workers and staff to stay in the market.
Accidents/tools: Accidents on construction sites are considered likely, therefore this aspect represents a high risk for the workers' work rate, and it is ranked 13th on the questionnaire. Minor accidents could affect the project schedule, but with major accidents such as deaths, the project will stop totally. Nevertheless, a combination of workplace security regulations and permanent instructions about workplace security in Australia can minimise the risk of an industrial accident.
Breakdown: Failing to report tool and equipment breakdowns can cause the work to slow down and fail to progress or be achieved poorly. It could have a crucial impact on the building work rate.
Lack of devices and machinery: Shortages of the devices and machinery will cause a delay in the workplace and the project will stagnate. In the same time, lack of equipment/tools can affect the work rate and cause delay in the project delivery date and cost overrun.
Q16. Please indicate any additional factors that you consider will significantly affect productivity in the construction industry.

Q17. Do you consider that the level of industry productivity has changed over the last five years and if so, how and why?
Q18. What are the most significant changes that governments in Australia could make to improve construction productivity?
Q19. What are the most significant changes that you or your company could do to improve construction productivity?

Table 5.7 Ranking comparisons between Delphi second round survey and standard first round survey

FACTORS	Delphi second round survey			First round standard survey	
	RII	Ranking	Frequency	RII	Ranking
Rework	0.686	2	1	0.92	1
Incompetent supervisor	0.740	1	4	0.90	2
Incomplete drawing	0.653	3	5	0.75	3
Work overload	0.540	6	6	0.60	4
Poor communication	0.746	1	2	0.59	5
Lack of material	0.626	4	3	0.58	6
Poor site conditions	0.493	10	6	0.51	7
A poor site layout	0.546	6	7	0.51	7
Overcrowding	0.546	6	7	0.51	7
Inspection delay	0.453	12	12	0.51	7
Absenteeism	0.526	8	11	0.50	8
Worker turnover	0.566	5	8	0.50	8
Accident	0.480	11	5	0.47	9
Breakdown	0.500	9	5	0.47	9
Lack of tools & equipment	0.533	7	4	0.47	9

Comments and explanations will be detailed in the next chapter (Chapter 6).

Table 5.8 RII calculations for each individual group (the impact on the process)

FACTORS	Academic Group (1)				Consulting Group (2)				Public Works Group (3)				Construction Group (4)			
	Total#	Total Score	RII	Rank	Total#	Total Score	RII	Rank	Total#	Total Score	RII	Rank	Total#	Total Score	RII	Rank
Rework	5	39	0.78	3	4	22	0.55	4	3	20	0.67	6	3	22	0.73	2
Incompetent supervisor	5	44	0.88	1	4	28	0.70	1	3	14	0.47	9	3	25	0.83	1
Incomplete drawing	5	35	0.70	5	4	25	0.63	3	3	16	0.53	8	3	22	0.73	2
Work overload	5	26	0.52	11	4	12	0.30	13	3	23	0.77	3	3	20	0.67	3
Poor communication	5	41	0.82	2	4	27	0.68	2	3	25	0.83	1	3	19	0.63	4
Lack of material	5	38	0.76	4	4	20	0.50	6	3	21	0.70	5	3	15	0.50	6
Poor site conditions	5	30	0.60	7	4	11	0.28	14	3	19	0.63	7	3	14	0.47	7
A poor site layout	5	32	0.64	6	4	13	0.33	12	3	22	0.73	4	3	15	0.50	6
Overcrowding	5	29	0.58	8	4	11	0.28	14	3	24	0.80	2	3	18	0.60	5
Inspection delay	5	21	0.42	12	4	15	0.38	10	3	20	0.67	6	3	12	0.40	9
Absenteeism	5	28	0.56	9	4	17	0.43	9	3	21	0.70	5	3	13	0.43	8
Worker turnover	5	30	0.60	7	4	21	0.53	5	3	23	0.77	3	3	11	0.37	10
Accident	5	30	0.60	7	4	18	0.45	8	3	16	0.53	8	3	8	0.27	11
Breakdown	5	27	0.54	10	4	14	0.35	11	3	22	073	4	3	12	0.40	9
Lack of tools & equipment	5	26	0.52	11	4	19	0.48	7	3	23	0.77	3	3	12	0.40	9

Table 5.9 RII calculations for each individual group (frequency of occurrence)

FACTORS	Academic Team (1)				Consulting Team (2)				Public Works Team (3)				Construction Team (4)			
	Total	Total Score	RII	Rank	Total	Total Score	RII	Rank	Total	Total Score	RII	Rank	Total	Total Score	RII	Rank
Rework	5	25	0.50	1	4	27	0.68	1	3	14	0.47	1	3	15	0.50	2
Incompetent supervisor	5	19	0.38	4	4	22	0.55	2	3	7	0.23	6	3	12	0.40	3
Incomplete drawing	5	18	0.36	5	4	27	0.68	1	3	9	0.30	4	3	19	0.63	1
Work overload	5	15	0.30	6	4	16	0.40	5	3	7	0.23	6	3	6	0.20	9
Poor communication	5	21	0.42	2	4	21	0.53	3	3	9	0.30	4	3	11	0.37	4
Lack of material	5	20	0.40	3	4	22	0.55	2	3	10	0.33	3	3	7	0.23	8
Poor site conditions	5	15	0.30	6	4	9	0.23	8	3	10	0.33	3	3	6	0.20	9
A poor site layout	5	14	0.28	7	4	14	0.35	6	3	13	0.43	2	3	8	0.27	7
Overcrowdin g	5	14	0.28	7	4	11	0.28	7	3	9	0.30	4	3	5	0.17	10
Inspection delay	5	7	0.14	12	4	9	0.23	8	3	9	0.30	4	3	9	0.30	6
Absenteeism	5	9	0.18	11	4	16	0.40	5	3	7	0.23	6	3	10	0.33	5
Worker turnover	5	13	0.26	8	4	20	0.50	4	3	9	0.30	4	3	7	0.23	8
Accident	5	10	0.20	10	4	11	0.28	7	3	8	0.27	5	3	6	0.20	9
Breakdown	5	9	0.18	11	4	13	0.33	6	3	8	0.27	5	3	7	0.23	8
Lack of tools & equipment	5	11	0.22	9	4	16	0.40	5	3	9	0.30	4	3	7	0.23	8

5.6 CONCLUSION

In this chapter, the Delphi method was used to create consensus because of its well-known technique. It was used in this study to gather information from a group of experts project managers from the construction industry through a questionnaire survey. The Delphi technique can be carried out in two or three stages and the data collected in the first stage is summarized and used for discussion in the next stage. The data obtained from the second or third stages form the consensus required. Enshassi et al. (2007) describes an ‘Accepted Delphi Technique’ in the following way: ‘It is a survey where it is steered by a monitor team, consisting of a number of stages of a team of experience, and they are anonymous to each other. At the end of each survey round, a standard feedback about the statistical group assessment calculated from the median and quartiles of single prognoses is given and if possible, the arguments and counter argument of the extreme answers are fed back'.

This chapter, handled the questionnaire design, selecting the panel of experts, data analysis, research strategy explanations, the Delphi methodology used, data tabulation of Delphi survey responses, calculating the relative importance index (RII) for the experts' survey responses, Critical success factors ranked according to their RII table 5.1 & RII calculations for Delphi responses (frequency of occurrence) table 5.5, and Ranking comparisons between Delphi second round survey and standard first round survey table 5.7

CHAPTER 6
RESEARCH DISCUSSION AND EVALUATION OF RESULTS

6.1 INTRODUCTION

The problem of critical success factors in the building industry is a worldwide incident and the building industry in Australia is not a special case. The aim of all groups participating in building projects such as proprietors, contracting firms, architects and engineering specialists in both government and individual businesses is finishing the project on time, at minimum cost, with the best work standard and the safest work rules. The following two factors, the success aspects that assist project groups to realise their aims as decided or the critical productivity problems that prevent or delay the project finishing, sometimes affect building projects.

The essential goal of this research is to recognise the critical success factors/aspects that can assist project participants to realize their planned aims with a high capacity.

The researcher drew out 15 of the most substantial success aspects, with respect to the study survey, and then examined the relationships among these factors to conclude which factors were preventing productivity problems.

This study has applied an inclusive literature survey to plan and administer a survey to examine the critical success factors, thereby obtaining general agreement by applying the Delphi technique to validate the required success factors for the Australian building industry. A pilot questionnaire was designed and delivered to experts from academia, contracting firms, public works, and an architect to investigate the important success factors/aspects. A comprehensive questionnaire was then delivered to investigate the relationships among the recognised 15 most substantial success aspects elected. A general agreement through applying the Delphi method was employed to rate the important success aspects for the Australian building industry.

The collected information from the questionnaire was analysed through a mathematical approach to recognise the most important explanations for the critical success factors in order to rank the importance of each aspect, and to assess the impact of each aspect on construction productivity.

A relative importance index (RII) was usually applied to assess the relative significance of the assorted reasons for the critical success factors/aspects.

Delphi methods, applying the general agreement from an expert group, have been used to recognise the 15 aspects that usually influence construction productivity and enhance construction projects' productivity efficiency.

6.2 EXPLANATION FOR DELPHI SURVEY INFORMATION CALCULATION

With respect to Delphi data analysis and calculations, a reasoning guideline should be set up to assemble and organise the outcomes and perceptions supplied by the Delphi information. Nonetheless, the types of measurement used to define and determine the general agreements in Delphi research are open to interpretation. A general agreement on an issue can be determined if a specific ratio of the responses fall between certain range (Ameyaw et al. 2016; Miller 2006). One test for judgment advised that general agreement could be reached by having 80% of the subjects' votes falling between two ranges on a seven-mark scale (Ulschak 1983). Green (1982) advised that minimum 70% of Delphi subjects are required to rate 3 or more on a 4-point Likert-type scale and the median should be 3.25 or more. (Scheibe, Skutsch & Schofer 1975) stated that applying a percentage scale is not accurate. They propose that a more accountable substitute is to measure the stability of the replies in consecutive iterations.

In a Delphi procedure, information calculations can be associated with both qualitative and quantitative information. Researchers require qualitative information if regular Delphi methods, which apply open-ended questions to canvass matters, are administered in the primary iteration. Consequent iterations are to recognise and to reach the required standard in addition to any variations of judgment between panellists. The main statistics employed in the Delphi approach are scaling of averages (means, median and mode) and the standard of diffusion/scattering (standard deviation and inter-quartile range) for presenting data dealing with the collected judgments of participants (Hasson, Keeney & McKenna 2000).

In most cases in Delphi surveys, applying the median and mode is favoured for presenting data regarding the collected opinions of participants. Nevertheless, sometimes, as noted by (Murray & Jarman 1987), the average/mean is in addition workable. Witkin (1984) examined the suitability of applying the average/mean to scale the replies if 1-2-3-4 measures applied in a Delphi method are not defined at identical periods. Applying the middle/median scores, using Likert-kind scales, is highly favoured (Eckman 1983; Hill & Fowles 1975; Jacobs 1996). Considering the expected general agreement of judgement and the distortion of anticipation of the replies as it collected, the middle/median is considered very appropriate to represent the resultant concurrence of judgement. On the other hand, applying the technique/mode is well suited as well when recording information in the Delphi procedures (Jacobs 1996). The Delphi approach has the intention to construct concurrence, however normally this is for one spec. If there is the chance of polarization or group of the conclusion nears two or more points. In this situation, the average/mean or middle/median could be confusing, (Ludwig 1994).

The Delphi approach supplies to those willing to be involved in the study assessments, inquiries, issue investigations, or discovery of what is normally recognised or unrecognised about any particular matter with an adaptable and responsive device for collecting and analysing the required information. The subject choice and the time limits for using and achieving a Delphi research are two major issues that should be decided before establishing the research. Extra care should be taken with regard to a low reply ratio, accidental direct responses and scrutiny of the members of the panel regarding their experience before deciding their expert judgments must be added to the design stage and execution of the research. The Delphi approach remains a reliable method for gathering essential information about large operations for researchers who want to collect data from experts who are deeply involved with the issue of interest and can supply actual-time and actual-world backgrounds.

6.3 DELPHI SURVEY SUMMARY OF DATA COLLECTION

In this research, to eliminate the weakest points in the findings from the first survey required an extra and very specific study and, precisely, the important aspects of redo/rework, unskilled supervisors, and unfinished designs. The rest of the aspects influencing the building work rate had to be examined more deeply.

The Delphi technique was used because to validate this study; a comprehensive examination of the essential results of the questionnaire with building expert project managers was completed. The aim of this investigation was to either confirm the findings of this research or identify points of difference between the two groups and discover promising procedures to reduce the influence of those aspects which were evaluated through this study to have the highest influence on the building work rate. An efficient scheme for enhancing the construction productivity in the Australian situation is proposed as an outcome from this research in the last chapter in this thesis. The replies to the Delphi questionnaire were tabulated and examined by applying a dispersion-rating table to write an explanatory note for the average/mean, middle/median rating, and order of importance (mode) for every reaction, as indicated in Table 6.1.

Table 6.1 Delphi survey final results (expert panel) – mode for ranking and frequency of occurrence

FACTORS	Ranking			Frequency		
	Average Mean	Median rank	Mode	Average Mean	Median rank	Mode
Rework	6.8	7	6	5.4	6	7
Incompetent supervisor	7.4	8	8	4.0	3	3
Incomplete drawing	6.5	7	8	4.8	4	2
Work overload	5.4	6	7	2.9	2	2
Poor communication	7.4	8	8	4.1	5	6
Lack of material	6.2	7	8	3.9	4	4
Poor site conditions	4.9	4	4	2.6	2	2
A poor site layout	5.4	6	6	3.2	3	3
Overcrowding	5.4	6	6	2.6	2	2
Inspection delay	4.5	5	5	2.4	2	2
Absenteeism	5.2	5	5	2.8	2	2
Worker turnover	5.6	5	5	3.2	3	4
Accident	4.8	6	6	2.3	2	2
Breakdown	5.0	4	4	2.4	2	2
Lack of tools & equipment	5.3	5	3	2.8	3	3

In Table 6.1, the following factors – unskilled supervisors, incomplete drawings, shortages or lack in construction material, and poor communication – have a value of 8 on the mode scale, which is high, with a frequency of occurrence between 2 and 6, which is also high? All these factors show some agreement with the first survey results (see section 6.4).

Table 6.2 RII calculations for each individual group (the impact on the process)

FACTORS	Academic team (1)				Consulting team (2)				Public Works team (3)				Construction team (4)			
	Total#	Total Score	RII	Rank	Total#	Total Score	RII	Rank	Total#	Total Score	RII	Rank	Total#	Total Score	RII	Rank
Rework	5	39	0.78	3	4	22	0.55	4	3	20	0.67	6	3	22	0.73	2
Incompetent supervisor	5	44	0.88	1	4	28	0.70	1	3	14	0.47	9	3	25	0.83	1
Incomplete drawing	5	35	0.70	5	4	25	0.63	3	3	16	0.53	8	3	22	0.73	2
Work overload	5	26	0.52	11	4	12	0.30	13	3	23	0.77	3	3	20	0.67	3
Poor communication	5	41	0.82	2	4	27	0.68	2	3	25	0.83	1	3	19	0.63	4
Lack of material	5	38	0.76	4	4	20	0.50	6	3	21	0.70	5	3	15	0.50	6
Poor site conditions	5	30	0.60	7	4	11	0.28	14	3	19	0.63	7	3	14	0.47	7
A poor site layout	5	32	0.64	6	4	13	0.33	12	3	22	0.73	4	3	15	0.50	6
Overcrowding	5	29	0.58	8	4	11	0.28	14	3	24	0.80	2	3	18	0.60	5
Inspection delay	5	21	0.42	12	4	15	0.38	10	3	20	0.67	6	3	12	0.40	9
Absenteeism	5	28	0.56	9	4	17	0.43	9	3	21	0.70	5	3	13	0.43	8
Worker turnover	5	30	0.60	7	4	21	0.53	5	3	23	0.77	3	3	11	0.37	10
Accident	5	30	0.60	7	4	18	0.45	8	3	16	0.53	8	3	8	0.27	11
Breakdown	5	27	0.54	10	4	14	0.35	11	3	22	073	4	3	12	0.40	9
Lack of tools & equipment	5	26	0.52	11	4	19	0.48	7	3	23	0.77	3	3	12	0.40	9

As illustrated above, Table 6.2 is a duplicate of Table 5.8. It has been reproduced for reference only.

6.4 KENDALL COEFFICIENT OF CONCORDANCE 'W'

There are two accepted measures of non-parametric rank correlations: Kendall coefficient of concordance (W) and Spearman's (rho) rank correlation coefficient.

Correlation analyses measure the strength of the relationship between two variables.

Kendall's W and Spearman's rank correlation coefficient assess statistical associations based on the ranks of the data. Ranking data is carried out on the variables that are separately put in order and are numbered.

Kendall coefficient of concordance (W) take the values between zero and plus one (i.e.

Kendall's W is a non-parametric measure of relationships between columns of ranked data. The W correlation coefficient returns a value of 0 to 1, where: (0) is no relationship /agreement, 0.10 is considered weak agreement, 0.30 is a moderate agreement, 0.60 is strong agreement and 1.0 is a perfect agreement / relationship).

Correlation analyses can be used to test for associations in hypothesis testing. The null hypothesis is that there is no association between the variables under study. Thus, the purpose is to investigate the possible association in the underlying variables. It would be incorrect to write the null hypothesis as having no rank correlation between the variables.

The main advantages of using Kendall's coefficient of concordance 'W' are as follows:

- W is linearly related to the mean value of the Spearman's rank correlation coefficients between all pairs of the rankings over which it is calculated.
- In most of the situations, the interpretations of Kendall's 'W' and Spearman's rank correlation coefficient are very similar and thus invariably lead to the same inferences.
- Kendall's W only gives the degree of association or agreement among the ranks assigned by different respondents on different attributes.

Kendall's coefficient of concordance 'W' gives the degree of association or agreement among the ranks assigned by different respondents on different objects or attributes or it is a measure of the agreement among several (m) quantitative or semi quantitative variables that are assessing a set of n objects of interest. In the social sciences, the variables are often people, called judges, assessing different subjects or situations. In community ecology, they may be species whose abundances are used to assess habitat quality at study sites. In taxonomy, they may be characteristics measured over different species, biological populations, or individuals.

The correlation and concordance are defined as follows:

- **Correlation**: a connection or relationship between two or more facts, numbers, etc.: for **example:** there's a correlation between smoking and cancer.

- **Concordance**: the state of there being agreement or similarity between things.

This method will be used here to study the correlation or agreement among the ranks assigned by the four groups of participants on fifteen different factors hindering the productivity in the construction industry Table 6.3.

Table 6.3 Kendall coefficient of concordance (W) the four individual group (the impact on the process table 6.2).

Factors	G1 R_1	G2 R_2	G3 R_3	G4 R_4	R	(R-A)	D^2= $(R-A)^2$
Rework	3	4	6	2	15	-10.86	117.93
Incompetent supervisor	1	1	9	1	12	-13.86	192.09
Incomplete drawing	5	3	8	2	18	-7.86	61.77
Work overload	11	13	3	3	30	4.14	17.13
Poor communication	2	2	1	4	9	-16.86	284.25
Lack of material	4	6	5	6	21	-4.86	23.61
Poor site conditions	7	14	7	7	35	9.14	83.53
A poor site layout	6	12	4	6	28	2.14	4.57
Overcrowding	8	14	2	5	29	3.14	9.85
Inspection delay	12	10	6	9	37	11.14	124.09
Absenteeism	9	9	5	8	31	5.14	26.41
Worker turnover	7	5	3	10	25	-0.86	0.73
Accident	7	8	8	11	34	8.14	66.25
Breakdown	10	11	4	9	34	8.14	66.25
Lack of tools & equipment	11	7	3	9	30	4.14	17.13
	A=∑R/N= 388/15 = 25.86				∑R= 388		S=1095.59

Where G1 means Group one (Academics) and R_1 is the ranking of the Academics. By using the following formula from (Frimpong, Oluwoye and Crawford, 2003; Moore, McCabe, Duckworth, and Sclove, 2003) to calculate "W"

$$[\ W= (12*S) / m^2\ N(N^2 - 1)\ ]$$

Where:

- A = total sum of ranks / number of ranks [A=(∑R)/N= 388/15 = 25.86]
- $R=R_1 + R_2 + R_3 + R_4$
- m is the number of Judges or respondents ranking the objects or attributes =4
- N is the number of attributes or objects that is evaluated by judges or

respondents =15

- S is the sum of $D^2 = \sum(R-A)^2 = 1095.59$
- 'W' is Kendall's coefficient of concordance

$$W = 12 * 1095.59 / 4^2 * 15(15^2-1) = 13147.08 / 53.760 = 0.2445$$

Therefore, the size of this coefficient of concordance (W= 0.2445) is > 0 and < +1.0 and it falls between the levels accepted for weak and moderate agreement among the four groups of the Delphi's clients (academics, consultants, contractors and public works) table 6.2. For example, three groups gave incompetent supervisors the same rank (number 1): academics, consultants, and public works but not with the contractors. On the other hand, Reworks has been ranked closely by three groups as 2, 3 & 4 except one group ranked # 6. Absenteeism has also been ranked closely as 9, 9 & 8 and one group ranked it as # 5, Work overload ranked 3, 3 and another two groups ranked as 11 & 13; Poor site condition ranked 7 by three groups except one group ranked 14; Accident ranked 7,7, 8 and one group ranked 11 and Communication was ranked by three groups as 1,1,2 and one group ranked 4 and so on in the rest of the factors.

Objective four (to analyse, using a unanimity expert group, the greatest critical success aspect of the Australian building industry and to evaluate the degree of agreement/ disagreement among project managers (using Delphi techniques) regarding the ranking of the relative importance index (RII), has therefore been met.

The degree of concordance 'W' among project managers concerning the ratings of aspects was decided in agreement with the Kendall Coefficient of concordance 'W'. The degree of concordance 'W' could be decided by the following formula

$$\mathbf{[W = (12*S) / m^2 N(N^2 - 1)]}$$

6.5 RELATIONSHIP BETWEEN CRITICAL SUCCESS FACTORS USING RELATIVE IMPORTANCE INDEX (RII) INTERACTION

The aspects recognised from the study survey, as assessed by the project parties from academia, engineers, public works, and contractors, were examined using a relative importance index (RII) to gauge their importance. The scale indicates that the academics' replies show meaningful interrelationships among the 15 factors. The conclusions of these interrelationships are as follows:

- Academics' responses demonstrate solid interactions among all the success aspects.
- Public works members' responses show strong correlations between the critical success factors.
- Consultants' replies demonstrate a high degree of interaction among all the success aspects.
- Contracting firm members' responses demonstrate solid interactions among all the success aspects other than for a few items (Table 6.2).

The results show solid connections between the critical success factors recognised in the study (Table 6.2). The conclusion shows strong interactions among these aspects for academics, architects, public works members, and contractors. The data analysis demonstrates an additional conclusion that academics and consultants agree on the meaningfulness of the interrelationships among the aspects.

6.6 COMPREHENSIVE SIGNIFICANCE OF ASPECTS

The general significance of the aspects for every examined group, and the research's complete achievement were assessed. The groups' significance ratings of the aspects are shown in Table 6.2.

The rankings given to aspects in this research are very different from those in another study (Ashley & Bonner 1987). The four groups ranked supervisor incompetence highest. Rework was considered the highest factor where it was ranked number 1 among three out of four groups. Poor communication was ranked as 2, 3, 4 and 4 among the four groups. On the other hand, poor communication was ranked number 1 as a critical success factor in the Delphi survey, Table 6.5.

There are a number of possible explanations for the different outcomes of the two surveys (the first round survey and the second round Delphi survey) and the contradiction in some rankings; for example, poor communication was ranked number

6 in the first pilot survey but number 1 in the Delphi survey. First, the research presented only the 15 aspects that could have a heavy impact. Second, the research goal was assessed through various project managers who were involved in the survey, in comparison with the research by Ashley and Bonner (1987), where information was gathered from different resources, each providing one moderate and one exceptional project in total.

Another reason could be that the rating of the aspects in this research was applied to projects during the building stages, but Ashley's investigation contained projects in various phases of completion. In addition, this research was limited to the Australian building industry, with respect to various circumstantial, bureaucratic, and developmental matters. More reasons might be other differences and individual competence in the building industry.

The finding of the questionnaire is a fresh ranking for the 15 aspects in preventing decline in building productivity in relation to structural procedures. The findings are established based on the significance of the aspects recognised in this study. This will be discussed in the study conclusion.

6.7 QUALITATIVE DELPHI SURVEY RESPONSES

The qualitative Delphi survey responses for Questions 16 to 19, the project managers' responses and recommendations, were self-explained as follows:

6.7.1 Question 16 is asking about the indication and any additional factors that the project managers consider significantly affect the work rate in the building industry. The project managers responses' were as follows:

6.7.1.1 Academia (USQ): Market economic conditions impacting on availability of skilled tradesmen, unnecessary movement of materials – materials delivered to site and not placed in a correct location intended for final assembly, Unnecessary movement of people, poorly planned working environment causing staff to unnecessarily move around the work place, overproduction (example: excess concrete or mortar, waiting for materials to be delivered to site or for one actively to be completed prior to commencing of second activity. Industrial relations – union sector anomalies generated by economic stimulus or retardation. Regulatory planning and approvals plus headwork changes may inhibit some development. For Queensland the lack of daylight saving can cause issues for some contractors/contracts. A general lack of suitable skills in some trades and carelessness results in a poor level of finish. Therefore this requires rectification and re-works. I find that the attitude of many trades people is “near enough is good enough”. This attitude is also evident in some supervisors, which leads to costly defects at the end of the project.

6.7.1.2 Consultant (engineers): Poor planning, Most of the items that rated highly can be attributed to three factors. Poor planning. This is due to a couple of factors, mainly lack of skill or knowledge in how to plan work properly and lack of experience. Accountability has been the buzzword around the industry for a few years now but the reality is still that many projects have unclear or undefined accountability structure, which leads to no one being accountable for anything. Performance management has been and will always be poorly done. It is easy to be critical behind closed doors but a lot harder to actually confront people about poor performance, especially at an initial phase when variation could happen. Lack of integration between design, procurement, and construction functions, leading to less than optimal construction/fabrication methodologies being adopted and more rework during construction, and this is related to communication problems between the project parties. This is usually accompanied by lack of detailed planning. In many cases clients separate design from construction in the belief that they can obtain a more transparent competitive tendering process to drive this. This gets confused for efficiency. Lack of depth in the Australian manufacturing industry means we rely on overseas supply. Australia is a minor market for many overseas suppliers and manufacturers, and therefore the service and timing to obtain construction inputs is often a factor in inefficiency of delivery.

6.7.1.3 Public works (project managers): Selecting skilled labour, and abandonment of apprenticeships, cadetships by the government and industry to save costs. It causes loss of skills transfer. Schedule and planning of the works. Empowering people to make timely decisions. Risk management, contingency plans. Providing sufficient number of skilled resources. As can be seen from newspaper reports, the impact of third parties on the project can be important. The mitigation is likely to be aligned to ensuring behaviour is managed within society's accepted norms. The newspaper reports refer to earlier investigations, which are likely to have recommendations, which would add value to this

6.7.1.4 Research.

6.7.1.5 Contractors (project managers): Cultural, behaviour, training, experience, work ethics. Location of the site relevant to major centres, and time for goods/people to travel. Wet weather should be considered in scheduling.

6.7.2 Question 17 was asking if the level of industry productivity has changed over the last five years and if so, how and why? The project managers responses' were as follows:

6.7.2.1 Academics (USQ) Generally, I believe the industry has become more efficient. The skill of the construction site managers and project manager has generally improved and there is more logic and methodology to construction programming than previously. Contractors' availability and pricing has been volatile on the back of the 2009 GFC and the resource draw towards the mining and gas sectors. Increased level of tertiary-trained skilled principal contractor personnel has increased the efficiency and productivity of the build. You would expect that the increase in technologies and with better work practices that productivity would increase. I believe though, with the continuation of workplace health and safety requirements, that productivity is stifled to a point where we have become less productive.

6.7.2.2 Consultant (project managers): No, I do not believe it has changed. The level of productivity produced vs. the wages earned has certainly decreased. A sense of entitlement clearly exists within the industry. Not significantly, other than to notice that there is an increasing burden of documentation required by clients, which increases costs for construction and increases risks for the constructor.

6.7.2.3 Public works (project managers): Yes, there are a lot better tools available specifically designed for the job. There are better materials available that are easier to use and give better performance. Material is often factory-assembled which reduces site time and limits exposure to weather conditions which damage the materials. There is a better understanding of modern construction techniques, which give improved efficiency, e.g. slip for misty, concrete piling techniques. Yes, however, the complication of projects has increased to meet regulatory and legislative requirements. Increased by improved design and equipment and training. The key is to align all sectors of the industry (finance, design, construction, maintenance and operations) within a safety and productivity context. The key is to have clarity around all contributors to the project.

6.7.2.4 Contractors (project managers): Yes, affluence. Communication has improved using email/phone/text etc. Constant change in work levels due to economic conditions makes it difficult to retain staff and provide training or apprenticeships. Yes, due to smaller margins and economic outlooks, companies must run more productively to be profitable.

6.7.3 Question 18 was asking about the most significant changes that governments in Australia could make to improve construction productivity?

6.7.3.1 Academics (project managers): Invest in infrastructure; incentivize tertiary institutions to deliver training (affordable) across all construction professions and trades; financial incentives to construction firms to invest in apprentices, plus provide a progressive salary scale. To form a working group similar to the construction excellence in the United Kingdom with the aim of driving change in the building business. The objective is to improve industry performance in order to produce a better and more efficient built environment across all sectors and within the supply chain. Relax OH &S requirements and work with industry to develop solutions that are more workable.

6..7.3.2 Consultant (project managers): Removal of unions. A recent example, over the Easter holiday period the union workers all had EBA rostered days off. This created poor productivity last week, not being able to operate the tower crane etc. Despite these being rostered days off, many of the union workers wanted to work, as they had no leave entitlements up their sleeves. Despite this, they were still not allowed to work because of the union. Investment in skills training by making higher education more affordable, especially when it is employer sponsored. We have project managers that are engineers with no financial training, for example, but are tasked with managing multimillion-dollar contracts. Clearly, they will not get this from being on the job and need further education. Contract models, rather than the more and more onerous commercial penalties and documentation requirements that predominate at present. The government could free up the rigidity of labour agreements by minimising the role of unions being a direct party to labour agreements and by allowing individual agreements. I think the biggest change would be for clients to be willing to adopt more collaborative/incentivised construction.

6.7.3.3 Public works (project managers): The Northern Territory Government should change the form of the contract to a more modern version. Government should embrace the quality assurance philosophy. Contractors need to embed more engineering capability in their organizations. Governments need to better understand risk management practices so that risks are addressed proactively. The government needs the utility to close roads for a periods of time i.e. make big decisions which may inconvenience some people for a short time, in order to gain improvements in productivity and reduce the project duration. Develop an approach to ensure that the workforce is able to be to deliver for the design and construction entities. There is a need for third parties to manage their input within society's expectations of behaviour.

6.7.3.4 Contractors (project managers): Promote accountability and responsibility. Provide more incentives for training/apprentices. Develop a fairer system of awarding projects as price is still too dominant in the decision process, i.e. the cheapest is not always the best or the best final price after variations and disputes, i.e. spend more time developing quality drawings and specifications using a baseline for minimal entry of drawings, have a reward system for contractors that point out issues, problems with the documents during the tender period, that are rewarded for raising problems early before they are built and need to be fixed on site. Remove red tape for development applications and streamline the requirements for local councils to be uniform.

6.7.4 Question 19 was asking for the most significant changes that you as a project manager or your company could do to improve construction productivity?

6.7.4.1 Academics (USQ): Commitment to invest in quality thoughtful design, which would flow into a sound financial, builds assets. Devise a set of KPIs to suit the institution and benchmark KPIs against industry standards. In our institution, we endeavour to provide the most complete design possible including all client stakeholder input at the earliest stage. In our experience, most delays arise from the design and approvals stage, rather than post detail design approval. Investing the time up front is always worth doing. In terms of the construction phase, we engage independent project managers and quantity surveyors to oversee the larger projects. Internal staff provide the client-side project management and oversight of the overall project. This works well and we consciously keep a close relationship with the contractor and the service providers described earlier. Our approach is non-adversarial and we seek to create an excitement and engagement from all parties associated with our project. If there is a passion then projects tend to go more smoothly. We also manage local site factors in order to minimise disruption or interruption of the contract and this can be challenging on the institution. To streamline productivity we must endeavour to provide the best documentation possible and ensure that the workplace is readily accessible. Unfortunately, there are factors which limit these, including imprecise OH &S requirements to the point where, if these were the controlling element, our productivity would halve. Often, I believe that those who work in OH &S have no real idea of the practical implications of their role.

6.7. 4..2 Consultant (project managers): Better project pre-planning and resource levelling. This is primarily associated with planning the works so the amount of labour on site is at a constant level, rather than having peaks and troughs. Have a structured approach to up skilling people, make the performance management process simpler, and improve planning, especially around sourcing senior managers for large projects. Use more alliance contracts.

6.7.4.3 Public works (project managers): Develop an enthusiasm for the business case to consider all risks and in particular develop an understanding that a “firm but fair” approaching to contracting brings benefits to client, designer, contractor, maintenance and operator. Recommended because this aligns all to how to deliver the best value and efficient and safe operation without excessive transfer to parties unable to carry or price the risk.

6.7.4.4 Contractors (project managers): We have been finding that design and construct type packages are becoming more desirable to clients, as they believe that the likelihood of variations is reduced, and we should promote this concept more as a viable option. By empowering employees and creating a positive environment, which leads to a higher morale, productivity and reduces turnover of staff and HR issues.

Calculating the relative importance index (RII)

The following formula of the relative importance index (RII) is applied to decide project managers' approach to the relative importance of basic achievement sign in Australia's construction works. The RII is figured out as follows (Tengan, Callistus1; Anzagira, Lee Felix; Kissi, Ernest; Balaara, Stephen; Anzagira, Che Andrew, 2014).

$$RII = \frac{\sum \text{W}}{(\text{A x N})}$$

Where:

W = measurement likely to every aspect by participants varying between 4 heights and 0 for nil answer as follows (4, 3, 2, 1, 0)

A = highest measurement = 4

N = the entire number of the participants

Table 6.4 Ranking comparisons between Delphi second round expert survey and standard first round survey

FACTORS	Delphi second round survey			First round standard survey	
	RII	Ranking	Frequency	RII	Ranking
Rework	0.68	2	1	0.92	1
Incompetent supervisor	0.74	1	4	0.90	2
Incomplete drawing	0.65	3	5	0.75	3
Work overload	0.54	6	6	0.60	4
Poor communication	0.74	1	2	0.59	5
Lack of material	0.62	4	3	0.58	6
Poor site conditions	0.49	10	6	0.51	7
A poor site layout	0.54	6	7	0.51	7
Overcrowding	0.54	6	7	0.51	7
Inspection delay	0.45	12	12	0.51	7
Absenteeism	0.52	8	11	0.50	8

Worker turnover	0.56	5	8	0.50	8
Accident	0.48	11	5	0.47	9
Breakdown	0.50	9	5	0.47	9
Lack of tools & equipment	0.53	7	4	0.47	9

With regard to the example of experienced nationwide project managers who participated in the Delphi second round survey (Table 6.4), some of these results show agreement, such as site overcrowding and poor site layout, each ranked six and seven, and Lack of tools & equipment ranked # 7 and # 9 in both surveys respectively. There is an average agreement on several of the factors, but other factors have some disagreement, such as rework, ranked second in the Delphi survey but in the first survey ranked first. Incompetent supervisors in the Delphi survey ranked first but in the first survey ranked second. Work overload was ranked six but in the first survey was fourth . Communication was ranked in the Delphi survey first but in the first survey fifth ; all these factors represent very marginal differences. In addition, the following factors – poor site conditions, inspection delays, work turnover, absenteeism, machinery breakdown, and shortages of devices and machinery – also have some inconsistency between them.

Table 6.4 shows significant differences in perceptions for the ten following factors: rework, incompetent supervisor, work overload, communication problem, unsuitable working location environments, inspection delays, worker turnover, breakdowns, and shortages of devices and machinery, between all project managers in the first survey and the experts in the second, Delphi survey. The first significant difference is that the RII values for each of the ten factors in the Delphi survey are higher or lower than in the first survey. These differences indicate that the expert team had beliefs and perceptions very different from those of the project managers in the first survey for the same factors.

The Spearman's rank correlation coefficient or Kendall’s tau can be used to measure the correlation between the two surveys (Delphi survey and the standard survey) as follows.

What is Kendall’s tau (Weichao et al. 2013)

- A rank correlation coefficient.

- The greater the number of inversions the smaller the coefficient will be.
- Range : [-1.0 to +1.0]
- Cannot square the correlation to get a coefficient of determination.

The formula :

Kendall's tau = (C - D) / (C + D)

Where **:** **C**: is the number of concordant pairs

D: is the number of discordant pairs

Concordant pairs: the number of observed ranks below a particular rank which are larger than that particular rank.

Discordant pairs: the number of observed ranks below a particular rank which are smaller in value than that particular rank

Table 6.5 Kendall's tau – for table 6.4

FACTORS	Standard Ranking	Delphi Ranking	Concordant C	Discordant D	Remarks
Rework	1	2	12	2	
Incompetent supervisor	2	1	12	0	
Incomplete drawing	3	3	11	1	
Work overload	4	6	7	3	
Poor communication	2	1	10	0	
Lack of material	6	4	9	0	
Poor site conditions	7	10	2	6	
A poor site layout	7	6	5	1	
Overcrowding	7	6	5	1	
Inspection delay	7	12	0	5	
Absenteeism	8	8	2	2	
Worker turnover	8	5	3	0	
Accident	9	11	0	2	
Breakdown (tools &equipment)	9	9	0	1	
Lack of tools & equipment	9	7	0	0	
SUM			78	24	

Kendall's tau=(C - D) / (C + D)

Kendall's tau = (78-24) / (78+24) = 54/102= 0.5294

Kendall's tau = 0.5294 (-1.0 to +1.0).

This is the Kendall's tau, you find the larger values, and ranking in Delphi survey is corresponding with the same in the standard survey values and ranking because it is a linear association between the rankings.

Therefore, the size of this (Kendall's tau = 0.5294) is ranked between (-1.0 and +1.0) which indicates that there is a moderate agreement among these factors (Lindskog, McNeil & Schmock 2003).

The factors with high influence on the construction productivity (Table 6.5) are the following:

Poor communication and problems among the participant groups; because a number of different groups share the many activities in a given project (for example, proprietors, architects, contractors and contracting firms), the communication among the project participant groups is very critical for achievement of the project. Perfect communication avenues among the different groups should be initiated in the preparation phase. Difficulties with communication can cause severe confusion and for this reason affect productivity due to interruptions in carrying out the project. Problems include the following. Because communication plays a vital rule in any organization, either in the head office or on the construction sites, therefore it is suggested to create a communication group to manage the entire project staff during the whole of the project. The performance and authority of such a group are not apparently decided and various government or agents representing this project group. In general, there are no applicable managerial forms or communication plans connecting all the project groups during the whole of the project phases. Communication problems were ranked #1 with a RII of 0.74 on the Delphi survey, compared with a ranking in the first survey of #5 with a RII of 0.59 (Table 6.4). The reason behind this difference in ranking is the number of project managers who were surveyed in each round and the nature of the project they were handling and its location. These differences indicate that the expert team had beliefs and perceptions very different from those of the project managers in the first survey for the same factors.

In addition, rework, unfinished designs, unskilled supervisors, shortages of materials, work overload and unsuitable layouts were ranked quite highly on the Delphi scale.

These factors were ranked with RII values of 0.68, 0.65, 0.74, 0.620 and 0.54 respectively, where 0.999 is the highest and 0.100 is the lowest. These factors' frequencies of occurrence were ranked between 1 and 7 (see Table 5.5). The more often the factor occurs, the worse the effect it will have on productivity. At the same time, these factors scored strongly in the initial survey - see Table 4.10(a). They have been classified as the main aspect with high effects on the building work rate. The rest of the aspects are thought to have an average to strong influence on the work rate.

Rework ranked high in the importance order (mode), 6 in the Delphi scale (a higher rank is a worse effect). Its frequency of occurrence was ranked #1 (this means that rework usually occurs during a project life span). The rework RII value is 0.917 which ranked number 1 in the first survey, but in the Delphi survey ranked number 2 with a RII of 0.686. The result from the two rounds of the Delphi survey represents high influence on productivity (Table 4.10 a and Table 6.4) and confirms the consistency of the two surveys' results.

Organizations confront some matters difficult to understand in the building industry, which is the failure to turn bad details into good details. As an outcome, poor work and services sometimes arise that lead to rework. Occasionally, redo/rework happens through mistakes made in the design procedures. The mistakes surface down the road and have an adverse influence on the project's accomplishment. The lack of concentration on details, particularly through the design procedure, causes rework to be a common characteristic of the procurement procedures; the expenses of rework can reach 12.4% of the entire project budget (Love, Mandal & Li 2010). The rework expenses could reach even more than 12.4% because this percentage does not cover the project productivity schedule interruption, legal expenses, and more expenses stemming from the project's bad characteristics.

In order to eliminate or reduce the expenses and the impact of rework, it is important to know the causes which created the damaged work, and to plan the strategy required for an avoidance program to minimise or eliminate rework. A research investigation beginning with introductory analysis can be applied to recognise the main aspects which may affect rework in any project. The results from this study and from most modern research are the idea of system dynamics being enforced to create a group of effect diagrams that are unified to advance a theoretical original circle model which is implemented to decide on a comprehensive original framework for rework. Effective strategies for rework prevention must be designed and carried out to enhance the project achievement overall. For effective strategies to be created, there must be a thorough understanding of the causal structure of the rework events acquired. In addition, poor site layouts, overcrowding and accidents are ranked 7, 7 and 9 on the Delphi survey ranking scale with frequency of occurrences at 7, 7 and 5 respectively (Table 6.4). These results from both the first survey and the second Delphi survey are consistent.

Subcontracting firms' accomplishment: In many building projects, there are some subcontracting firms that are handling the projects through the main contractors or owners. The project could be finished on time if subcontracting firms have the capability. The project will be interrupted and out of schedule if the subcontracting firm is unskilled.

Insufficient contractor background: insufficient contractor knowledge is a vital aspect influencing the project work rate. This can be connected to the contract-assignment process whereby many projects are assigned to the minimum tender and regional contracting firms, alone or through shared deals, are assigned broad and complicated projects where they do not have enough working skills because of the limited approach to the international construction market for competing in the old days.

The rest of the aspects have factors with average effects on the building productivity as follows: poor site conditions, breakdowns, and shortages of devices and equipment have a moderate or less impact on construction work rate. Their rankings on the Delphi scale in the second round were 10, 9, and 7 respectively, with frequency of occurrence 6, 5 and 4 respectively. In addition, these three factors were marked lower in RII in the first round (Table 4.10 a) and ranked 4, 9 and 9; therefore, they are anticipated to have an average or less impact on the building work rate.

6.8 CONSTRUCTION PRODUCTIVITY DIFFICULTIES CORRELATED WITH DIFFERENT NATIONS

Many researchers performed examinations of the productivity difficulties in different nations (both developed and developing), and many of these nations have applied various aspects. Concerning the comparison between the conclusions achieved earlier with this research, eight aspects were chosen by another researcher. The rating of these aspects is shown in Table 6.6.

To this point, the conclusion shows that the shortage of building material is the most critical productivity obstacle worldwide, but not in Australia, as a developed country, because it has been ranked number 6 with a RII of 0.58 in the first round of the Delphi survey and ranked number 4 with a RII of 0.62 on the second round of the Delphi survey, and ranked number 3 in frequency of occurrence. In advanced nations, there is less difficulty with supervisor skills than in growing nations. At the same time, both types of nations experience the effects of rework to the same degree. Advanced nations experience more problems from absenteeism of the workplace, but not in Australia, where absenteeism was ranked 8 and 8 on both surveys (round one and round two 'Delphi') and its frequency of occurrence was ranked number 11.

In addition to the previous explanations, when concentrating on advanced nations, the conclusions of the research, as shown in Table 6.8, were rated on a number gauge and so, unfortunately, a deep investigation could not be used (Kaming et al. 1997 b), although Australia was ranked on a RII. Accordingly, this could be the reason why the work rate difficulties in Australia seem to vary from those of other advanced nations. Nevertheless, if the results are compared with three other advanced nations, it can be noted that Thailand, Iran, and Nigeria have in common a similarity in their building rate difficulties. In Thailand and Iran, most of the common aspects are rated the same and are identical. The best three aspects and the worst three aspects in Nigeria and Thailand are also identical, but are varied in their ratings.

This study shows that the construction industry in Australia has some productivity difficulties. The research not only discloses the influence of aspects affecting the construction productivity, but also, if it is distinguished from former research results obtained by the same author, 8 of the 15 extremely effective aspects are alike. The eight aspects are shortages of building components, shortages of devices and machinery, incompetent supervisors, rework, and poor communication. These results indicate that there are some dissimilar productivity difficulties among project managers at the administration stage and among artisans at the functioning stage. Making a worldwide correlation, nevertheless, shortage of building components is the most effective aspect in the construction productivity in each nation examined. With respect to advanced and growing nations, there are many and various work-rate obstacles, in consequence of the fact that, for instance, supervising interruption causes more impact in advanced nations than in growing nations. Again, when contemplating the growing nations alone, these nations have very similar work rate/productivity differences, as the aspects were carefully rated.

Table 6.6 Comparison of some productivity differences shared with other countries

Aspects influencing the construction work-rate	Ranking									Remarks
	Australia 1st Survey	Australia 2ed Survey	USA	U.K.	Nigeria	Iran	Thailand	Indonesi a	Malaysia	
Shortage of building component	sixth	fourth	first	first	first	first	first	first	sixth	
Shortage of devices & machinery	nineth	seventh	second	fifth	second	third	fifth	second	eighth	
Redo/rework	first	second	third	second	fourth	second	third	third	10th	
Desertion of workplace	eighth	eighth	fourth	fourth	third	fifth	sixth	sixth	fifth	
Intervention	n/a	n/a	fifth	third	fifth	sixth	second	fifth	20th	
Supervisor delay (training session)	n/a	n/a	sixth	sixth	n/a	fourth	fourth	fourth	eighth	
Poor communication	fifth	first							ninth	
Incompetent supervisor	second	first							third	

Source: Kaming et al. (1997); Zakeri et al. (1996)

In another study by Kaming et al. (1997 b) about aspects affecting artisan work rates in Indonesia, in correlating work-rate difficulties with other nations gathered from the literature, a discrepancy between the aspects of the current research and those of earlier examiners can be seen and is tabulated in Table 6.7.

In general, the rating of productivity difficulties in the Indonesian building industry is very similar to those of other nations, with shortage of building components rated first, rework second, intervention third and desertion of the site fourth. In that research productivity issues were rated because of time missing because of work-rate obstacles by applying an intermission gauge, but the earlier research was rated on an ordinal gauge that created a comparative indicator for each of the aspects, so a deep investigation cannot be carried out. Nevertheless, at a glance, the outcome of this correlation in Table 6.8 (a) demonstrates that the building industries in four nations chose shortage of building components as a worldwide obstacle for both advanced and growing nations. Rework was rated second in growing nations, whereas advanced nations ranked that issue third. These two indicators show various degrees of significance between the construction productivity in advanced and growing nations. Nevertheless, plans of action for development will probably be dissimilar.

It is clear that constructive time is usually reduced at changing levels in Indonesia. Unproductive time amounted to 20% and 24.74% in the trades survey and activities examined, respectively.

The waste of constructive time was created by a series of difficulties, recognised in a downward structure as ‘shortage of the building components’ (30.7%), ‘redo/rework’ (20.1%), ‘deserting the working site’ (16.8%), ‘shortage of the right devices and machinery’ and ‘devices and machinery disintegration’ (12.2%) and ‘interventions’ because of poor organization of activities and inaccurate worker numbers (11.8%).

Table 6.7 a Ranking order for six severe factors shared with other five countries

Productivity problems	Indonesia Rank	Nigeria Rank	UK Rank	USA Rank	Australia Rank	Rem-arks
Shortage of building component	first	first	first	first	sixth	
Shortage of devices & machinery	fifth	third	fifth	second	ninth	
Intervention	third	sixth	second	fifth	n/a	
Absenteeism	fourth	fifth	sixth	sixth	eighth	
Superintendent delay, training session	sixth	fourth	fourth	fourth	n/a	
Redo/rework	second	second	third	third	first	

Source: Kaming et al. (1997) ; Olomolaiye (1988)

In Nigeria, the UK, and the USA, shortage of building components is a worldwide obstacle influencing construction productivity. On the other hand, a lot of attention has been given to rework difficulties in Indonesia and Nigeria, while the UK and the USA were concerned with interventions, devices and administration difficulties. It is noted that Indonesian artisans are well organised and on time. Time used for working by artisans in Indonesia is considered comparatively greater than that in Nigeria and the UK; even though this cannot lead to a higher work rate, essentially because of unskilled staff. The authorities and the other large building organizations and company partners in Indonesia are required to pay immediate and crucial attention to instruction and development of knowledge for building artisans.

Table 6.7 b Non-productive time because of productivity difficulties

Productivity Problems	Bricklayers		Carpenters		Steel fixers		Average	
	Hours	Rank	Hours	Rank	Hours	Ranks	Hours	Ranks
Lack of material	1.69	3	3.51	1	2.25	2	2.48	1
Lack of equipment	0.79	5	0.40	5	1.88	3	1.02	5
Interference	1.5	4	0.61	4	2.46	1	1.52	3
Absenteeism	2.38	1	0.56	3	0.85	5	1.26	4
Supervision delays	0.20	6	0.19	6	0.02	6	0.14	6
Rework	1.70	2	2.03	2	1.00	4	1.58	2
Total hours lost	8.26		7.30		8.46		8.01	

Source: Olomolaiye (1988)

6.9 STUDY DISCUSSION

This research has shown that there are some limited construction productivity difficulties in Australia and has ranked some of the most critical aspects that have an average to severe effect on Australian's construction productivity with respect to their relative significance index (RII) through the opinions of project managers inside the Australian building industry (Hughes & Thorpe 2014).

In general, 32 factors have been recognised as aspects affecting construction productivity (work-rates) globally, but in Australia the study's initial survey indicated that there are six critical factors: redo/rework, unskilled supervisors, unfinished designs, lack of materials, work overburdening, and poor communication, which have severe effects on productivity, while nine additional aspects have an average influence on the work rate: inadequate working location environments, defective working location planning, site congestion, examination interruptions, workplace desertion, workers' absence, accidents, device/machinery failure, and shortage of devices and machinery. Different causes of these aspects were investigated to find out how the work rate might be enhanced by relieving the impact of negative aspects (Hughes & Thorpe 2014).

The critical success aspects in the building procedures for building projects in Australia have been identified in this research. In brief, the six aspects in Table 6.5 with regard to the highest rated influences in the Delphi second round validation survey and the RII values in the first survey were: poor communication, rework, unfinished designs, shortage of building components, incompetent supervisors and worker turnover. The first five factors were ranked in the top six in the initial survey. This conclusion indicates that individual practical backgrounds (concerning project managers, supervisors, and artisans) in the work agreement are significant in achieving building works, and so the talents of supervisors, artisans and project managers should be highly regarded in relation to the expense of building projects. The reason is that their expertise could simply be passed onto the workers to apply, and this could be carried out when there are adequate classifications and trades cooperation through the groups participating in the activity.

The skills of the project managers who participated in the Delphi survey included 15 years and over of experience as project managers and construction managers (81% with 15 or extra years in their job, in different aspects of the building industry) and so they were likely to speak from their experience. Excluding the six severe factors mentioned above, the rest of the factors were classed as having only a mild impact on the building industry.

The discrepancy in the rating order of the aspects between the first and second rounds of data collection from the respondents in the two surveys can be explained as follows: a) It could be because the top few factors were seen slightly differently by the two groups. b) Simply because there were two very different groups in the two surveys. c) This study restricted the number of critical aspects to 15, which might have influenced their ranking. d) This study concentrated on the aspects in relation to building and structural procedures. e) The considered projects were private and public projects and were evaluated by different project participants. f) This research was limited to the Australian building industry, with its various circumstances and conditions such as: i) political; ii) cultural; iii) environmental.

In this study, two rounds of the Delphi survey process were carried out to achieve consensus. The Delphi approach objective was to decide via a variety of different techniques instead of depending on the records of the relevant aspects. On the other hand, the elected participants were highly qualified project managers with knowledge and experience in the Australian building industry. A consensus expert opinion has been applied to recognise the aspects to be considered in improving project achievements in the Australian building industry. The following is the final ranking list.

In the previous chapters (4 and 5), the questionnaire survey in the first round and the second round (Delphi survey) were explained; in brief, the questionnaire survey was well prepared with clarity and was unambiguous. A pilot survey was done for testing the strength of the survey, then distributed to the expert project managers; the information was collected and analysed by applying SPSS for the first round because the number of responses was high, but the second round was analysed manually because the number of experts was 20 and the total responses were 15 only (75%).

Table 6.8 The final ranking list for critical success factors from the second round of the Delphi survey.

Rank	Critical success factors	Rank	Critical success factors
1	Poor communication	6	Work overload
1	Incompetent supervisor	7	Lack of tools & equipment
2	Rework	8	Absenteeism
3	Incomplete drawing	9	Breakdown
4	Lack of material	10	Poor site conditions
5	Worker turnover	11	Accidents
6	A poor site layout	12	Inspection delay
6	Overcrowding		

This table was discussed in Chapter 5. The responses from the surveys were analysed and the results were tabulated in the above Table 6.7(a) with the following ranking for the most critical factors. Poor communication was ranked number 1 because it represents a very influential factor for construction productivity, then rework was ranked number 2 because of its influence on construction productivity and on cost overruns, and so on until inspection delay was ranked number 14, which means it has less effect on productivity.

6.10 THEMATIC ANALYSIS OF RESPONSES TO THE DELPHI SECOND ROUND QUALITATIVE SURVEY

The Delphi survey is a preferred method of collecting data and information about a specific subject as it allows input from different resources such as academia, consulting engineers, public works, and contractors in order to build up consensus solutions (Eckman 1983). The Delphi survey technique depends on research in which surveys assist the researcher to conclude the research outcome with a specific set of experts and the data is gathered from the respondents directly using a questionnaire survey or by face-to-face interviews (Eckman 1983).

The next sections describe the results of four qualitative questions (16, 17, 18 and 19 of the second round) asked of the experts, sequenced in the different ways – firstly by type of expert (academic, consulting engineers, public works and contractors), and secondly by analysis of the questions asked.

Table 6.9 Question 16 Any additional factors the project managers consider significantly affect productivity in the construction industry

Rank	Description	No of occurrences
1	Availability of skilled tradespeople	6
2	Accountability and structure for achieving accountability (including empowerment) – including the supervisor's attitude	5
2	Poor planning	5
3	Material availability	3
4	Economic conditions impacting on material supply and availability of tradespeople	2
5	Unnecessary movement of people	1
5	Overproduction	1
5	Regulatory planning and approvals, head works	1
5	Impact of third parties	1
5	Wet weather	1
5	Lack of integration	1
	Total	27

In the above Table 6.9 some of these new factors were not considered in the previous surveys, but were considered by the expert project managers significant and influencing the work rate in the building industry in Australia.

For example, availability of skilled tradesmen has been occurring and was stated six times in the experts' responses, which means that there could be a shortage of skilled tradespeople in the construction industry. It is well known that skilled tradespeople are very important and play a vital role in the construction industry because without them no work can be carried out and many reworks need to be done. In addition, it would cause a lot of delays in the schedule and delays in the project's completion date. All these will affect productivity and will cause cost overruns.

Accountability and structure; this is important for achieving accountability (including empowerment) – including the supervisor's attitude to responsibility and being an accountable person for the project works. Poor planning also has a serious effect on productivity and too much time being wasted for no good reason. These were repeated five times each, representing severe factors that could cause critical issues on both the construction site and the project management side as well.

Materials availability and economic conditions affecting material supply were noted three times and two times respectively, and represents another critical factor affecting work progress on construction sites and causing delays in project schedules.

Unnecessary movement of people, overproduction, regulatory planning and approvals, head works, lack of integration, impact of third parties and wet weather: all these factors have insignificant effects, but still create some problems on construction sites and cause delays and cost overruns. The factor of wet weather is considered one of the poor planning factors, because wet weather is the worst enemy of the construction industry. It causes delays and a project can stop for a number of days, even a number of weeks. The project scheduler should consider this factor in advance.

The supervisor’s attitude towards the tradespeople who are working under their supervision is extremely important because a good attitude will help in motivating the tradespeople to work harder and become more productive.

Lack of integration between the project members and the department’s handling the project, especially the stockholders or owners and the project heads: integration in the workplace could create harmony and understanding, and save time and money.

Table 6.10 Question 17 Do you consider that the level of industry productivity has changed over the last five years and if so, how and why?

Rank	Description	Frequency
1	No, I do not believe it has changed; The level of productivity produced vs. The wages earned has certainly decreased. Not significantly. Not significantly.	4
2	Tertiary-trained, skilled, the increase in technologies and with better work practices that productivity would increase. There is a better understanding of modern construction techniques.	3
2	Yes, there are a lot better tools available specifically designed for the job. Increased by improved design and equipment and training. Increased by improved design and equipment and training.	3
2	Yes, however the complication of projects has increased to meet regulatory and legislative requirements, Yes, due to smaller margins and economic outlooks, Yes, due to smaller margins and economic outlooks.	3
3	The industry has become more efficient, the industry has become more efficient.	2
3	There are better materials available that are easier to use and give better performance. Material is often factory-assembled which reduces site time.	2
4	The construction site managers and project managers have generally improved.	1
4	Contractors' availability and pricing has been volatile.	1
4	Yes, logic and methodology in construction, programming than previously.	1
4	Communication has improved using email/phone/text.	1
	Total	21

Table 6.10 discusses the level of industrial productivity and whether it has changed over the last five years and if so, how and why. Most of the responses gathered from the project managers were positive and the majority were satisfied with industry performance and the changes in the industry because of advanced technical equipment such as computers and construction software such as Microsoft Project Management and other programs, also the new, sophisticated construction equipment and tools. For example, with tertiary-trained management, skilled staff, and the increase in technologies, and with better work practices, productivity would increase. There is a better understanding of modern construction techniques; this was stated three times, which shows the satisfaction of the experts with the modern construction industry and the changes happening over the past 20 years.

The construction site managers and project managers have generally improved; this factor was nominated one time only. This is weak and insignificant in this quantitative analysis; also it forms some contradiction with the outcome of the first survey and the Delphi survey because its frequency of occurrence is insignificant. This factor was ranked number 2 with RII = 0.90 in the first survey and in the Delphi survey was ranked number 5 with RII = 0.65. The reason is the different views of the project administrators and the demographics of the projects.

The industry has become more efficient, there are better materials available that are easier to use and give better performance. Material is often factory-assembled which reduces site time; these factors have been stated twice and show a positive response to the changes and advances in the construction industry in Australia.

Some experts gave the following answers:

Yes, there are a lot better tools available specifically designed for the job. The productivity increased by improved design and equipment and training;
Yes, the construction industry has changed and improved; however, the complication of projects has increased to meet regulatory and legislative requirements; also improved due to smaller margins and economic outlooks.

All these testimonials from the experts' responses in the Delphi second round survey about the construction industry give very good indications that the industry in the last two decades has changed a lot due to advanced technology (computers and the software handling construction, new methods, advanced tools and equipment are helping to achieving the job with the highest quality and in a measurable time).

On the other hand, good training for tradespeople and apprentices on site or by joining an institute of Technical and Further Education (TAFE) or the tertiary education has helped in creating good quality tradespeople and management with high achievements on the site and improved construction productivity, and will help to reduce the rework problem. Overall, this mean that there is a reasonable chance of construction productivity achieving good results in the future.

Table 6.11 Question 18 What are the most significant changes that governments in Australia could do to improve construction productivity?

Rank	Description	Frequency
1	Removal of unions. The government could free up the rigidity of labour agreements. The Northern Territory Government should change the form of the contract to a more modern version.	3
2	Government should embrace the quality assurance philosophy. Contractors need to embed more engineering capability in their organizations.	2
3	Invest in infrastructure.	1
3	Incentive tertiary institutions to deliver training.	1
3	Form a working group similar to the construction excellence in the UK with the aim of driving change in the construction industry.	1
3	Governments need to better understand risk management practices.	1
3	Investment in skills training by making higher education more affordable.	1
3	Clients to be willing to adopt more collaborative/incentivize construction contract models.	1
3	Remove red tape for development applications and streamline the requirements for local councils to be uniform.	1
3	Spend more time developing quality drawings and specifications.	1
3	Provide more incentives for training/apprentices.	1
3	Develop a fairer system of awarding projects.	1
	Total	15

Table 6.11 is discussing the experts' responses to Question 18 (What are the most significant changes that governments in Australia could make to improve construction productivity?) It is noted that most of these responses were discussed in detail in previous questions. They are summarised blow.

Invest in infrastructure; this factor was mentioned one time and in fact investing in infrastructure is a vital source for creating a lot of jobs and a high return on investments, and for modernizing and upgrading cities, roads, and transportation to help the economy progress.

Incentivize tertiary institutions in delivering training; this factor was explained above. It will create very skilled project engineers, project managers for better management and skilled tradespeople to reduce rework and construction time, improve productivity and eliminate cost overruns.

Removal of unions. The government could free up the rigidity of labour agreements.

The Northern Territory Government should change the form of the contract to a more modern version, remove red tape for development applications, and streamline the requirements for local councils to be uniform; these factors have been repeated three times and one time respectively, and these two issues are of some importance to project improvement. These issues are for the government and the union to look at with some studies for consideration.

Governments and construction companies need to better understand risk management practices for mitigating risk; because this issue could cause many delays in the project progress beside the legal process and the cost of litigation.

Table 6.12 Question 19 What are the most significant changes that you or your company could do to improve construction productivity?

Rank	Description	Frequency
1	Quality thoughtful design, complete design, design and construction.	3
2	Project pre-planning. Improve planning.	2
3	The best documentation possible.	1
3	Devise a set of Key Performance Indicators (KPIs).	1
3	Upskilling people.	1
3	Empowering employees and creating a positive environment.	1
	Total	9

Table 6.12 is handling the responses of the expert project managers for question 19, which stressed the following points:

Quality and complete design to save time and delays in project process. Also, devising a group of Key Performance Indicators (KPIs) to keep project process under control and to improve project performance.

The best documentation possible to keep the project organized to save time and money and to easily get what you are looking for in an easy way and fast as well; project pre-planning and continuously improving planning are necessary to improve performance and productivity and to cut short unnecessary and non-productive time.

6.11 THE QUALITATIVE DELPHI SURVEY RESPONSES DISCUSSION

The expert project managers' responses and recommendations were explained as follows:

1- THE EXPERTS WITH ACADEMIC BACKGROUND

Q 16 – Regarding the indication and any additional factors that the project managers consider significantly affect productivity in the construction industry:

The academic staff responses were as follows:

I. Lack in experienced trades in the building market due to many tradespeople returning to education to get some qualifications of what they missed in their early life.

II. Materials misplaced and stored incorrectly lead to a lot of damage and wasting money and create shortages in the project budget.

III. Unnecessary movement of people.

IV. Poorly planned working environment causing staff to unnecessarily move around the workplace and this can be translated to wasting time and time is money.

V. Industrial relations can create some delays and fall behind schedule.

VI. Overproduction (e.g. excess concrete or mortar, waiting for materials to be delivered to site or for one activity to be completed prior to commencing of second activity; all these factors lead to material and time wasted i.e. wasting money and delay the project completion date.

VII. Regulatory planning and approvals, plus head work changes may inhibit some development.

VIII. A general lack of suitable skills in some tradespeople and carelessness results in a poor level of finish. Therefore, this requires rectification and reworks, this is will add more cost, and more delay in project completion date.

IX. The attitude of many tradespeople is "near enough is good enough". This attitude is also evident in some supervisors, which leads to costly defects at the edge of the task and make the task fall behind schedule.

These problems can be overcome by good supervision and highly regarded management.

Q 17 – Regarding the level of industry productivity, has it changed over the last five years and if so, how and why?

Academic expert responses stated the following:

I. Generally, I believe the industry has become more efficient.

II. The skill of the construction site managers and project managers has generally improved and there is more logic and methodology in construction programming than previously.

III. This is encouraging news about the construction industry because many construction companies have adopted the new technology and some software such as Microsoft Project, MS Office spreadsheets, PowerPoint for illustrations, and it keeps tracking the project steps first by first.

IV. Contractors' availability and pricing has been volatile on the back of the 2008 GFC and the resources drawn towards the mining and gas sectors.

V. Increased level of tertiary-trained, skilled principal contractor personnel has increased the efficiency and productivity of the construction and build.

VI. The increase in technologies and with better work practices that productivity would increase.

VII. The continuation of workplace health and safety requirements, that productivity is stifled to a point where we have become less productive.

Q 18 With respect to the most significant changes that governments in Australia could make to improve construction productivity.

The academic experts' (project managers') responses were as follows:

I. Invest in infrastructure to reduce useless time consuming.

II. Improve the skills and the new technology knowledge for tradespeople and staff of the construction companies by incentivizing tertiary institutions to deliver training (affordable) across all construction professions.

III. Financial incentives to construction firms to invest in apprentices to get experience in new trades, plus provide a progressive salary scale to improve the standards of living of tradespeople and create enthusiasm.

IV. To form a working group similar to the construction excellence in the UK with the aim of driving change in the building businesses . The goal is to improve industry performance in order to produce a better and more efficient built environment across all sectors and within the supply chain.

V. Relax OH &S requirements and work with industry to develop solutions that are more workable. Implementing all these suggestions will improve the construction productivity and the industry performance.

Q 19 Regarding to the most significant changes that the project manager or the construction companies could do to improve construction productivity**.**

Academic experts expressed their thoughts as follows:

I. Commitment to invest in quality.

II. Thoughtful design, which would flow into sound financials, and build assets.

III. Devise a set of key performance indicators (KPIs) to suit the institution and benchmark KPIs against industry standards.

IV. Some consulting institutions endeavour to provide the most complete design possible, including all client stakeholder input at the earliest stage because the expert's experience says that most delays arise from the design and approvals stage, rather than post detail design approval.

V. Investing the time up front is always worth doing in order to save time and keep the project on schedule.

VI. In terms of the construction phase, independent project managers and quantity surveyors are engaged to oversee the larger projects. In some projects internal staff provide the client-side project management and oversight of the overall project. This works well, consciously kept a close relationship with the contractor and the service providers described earlier.

VII. The expert's approach is non-adversarial and to create an excitement and engagement from all parties associated with the project. If there is a passion then projects tend to go more smoothly.

VIII. Also, managing local site factors in order to minimise disruption or interruption of the contract and this can be challenging on the institution.

IX. To streamline productivity, project managers must endeavour to provide the best documentation possible and ensure that the workplace is readily accessible.

X. Unfortunately, there are factors which limit these including imprecise OH &S requirements to the point where, if these were the controlling element, our productivity would halve. Often, they believe that those who work in OH &S have no real idea of the practical implications of their role.

2- THE VIEWPOINTS OF THE EXPERTS FROM THE CONSULTING ENGINEERING INSTITUTIONS

Q 16 – Regarding the indication and any additional factors that the project managers consider significantly affect productivity in the building industry.

The experts from the consulting engineering firms stated that :

I. Most of the items that rated highly can be attributed to three factors. a) Poor planning; this is due to a couple of factors, mainly lack of skills or knowledge in how to plan work properly and lack of experience. b) Accountability has been the buzzword around the industry for a few years now, but the reality is still that many projects have unclear or undefined accountability structure, which leads to no one being accountable for anything. c) Performance management has been and will always be poorly done because it is easy to be critical behind closed doors, but a lot harder to actually confront people about poor performance, especially at an initial step when alteration could be carried out.

II. Lack of integration between design, procurement and construction functions, leading to less than optimal construction/fabrication methodologies being adopted and more rework during construction and this is related to communication problems between the project parties.

III. This is usually accompanied by lack of detailed planning. In many cases, clients separate design from construction in the belief that they can obtain a more transparent competitive tendering process to drive this and it will cause confusion to the efficiency.

IV. Also, lack of depth in the Australian manufacturing industry means we rely on overseas supply because Australia is a minor market for many overseas suppliers and manufacturers; therefore, the service and timing to obtain construction inputs is often a factor in the inefficiency of delivery.

Q 17 Regarding the level of industry productivity, has it changed over the last five years and if so, how and why?

The experts' responses were as follows:

I. An expert stated that he did not believe it has changed because the level of productivity produced vs. the wages earned has certainly decreased and a sense of entitlement clearly exists within the industry.

II. Adding to that, there is an increasing burden of documentation required by clients, which increases costs for construction and increases risks for the constructor.

Q 18 With respect to the most significant changes that governments in Australia could make to improve construction productivity.

I. An expert suggested the removal of unions and gave this reason; in a recent example, over the Easter holiday period the union workers all had an Enterprise Bargaining Agreement (EBA) rostered day off. This created poor productivity, not being able to operate the tower crane etc. Despite these being rostered days off, many of the union workers wanted to work, as they had no leave entitlements up their sleeves. Despite this, they were still not allowed to work because of the union.

II. The government could free up the rigidity of labour agreements by minimizing the role of unions being a direct party to labour agreements and by allowing individual agreements. I think the biggest change would be for clients to be willing to adopt more collaborative/incentivized construction.

Q 19 Regarding the most significant changes that the project manager or the construction companies could do to improve construction productivity.

To improve the quality of the construction productivity, the government and constructions institutions should invest in skills training by making higher education more affordable, especially when it is employer-sponsored, because there are project managers that are engineers with no financial training; for example, they are tasked with managing multimillion-dollar contracts. Clearly, they will not get this from being on the job and need further education.

3 THE VIEWPOINTS OF THE EXPERTS FROM THE PUBLIC WORKS INSTITUTIONS

Q 16 Regarding the indication and any additional factors that the project managers consider significantly affect productivity in the construction industry.

The experts from public works recommended the following:

I) Skilled labour.

II) Abandonment of apprenticeships, cadetships by the government and industry to save costs and time delays.

III) Good schedule and planning of the works can save time and money.

IV) Empowering people to make timely decisions, plans for risk management, contingency plans and providing a sufficient number of skilled resources all will help to overcome construction’s critical factors.

Q 17 Regarding the level of industry productivity, has it changed over the last five years and if so, how and why?

The expert project managers gave the following statements:

I) For the factor of the tools problem, there are a lot better tools available specifically designed for the job.

II) In addition, there are better materials available that are easier to use and give better performance.

III) Material is often factory-assembled, which reduces site time and limit exposure to weather conditions, which damage the materials.

IV) There is a better understanding of modern construction techniques, which give improved efficiency, e.g. slip for misty and concrete piling techniques.

Q 18 – With respect to the most significant changes that governments in Australia could do to improve construction productivity.

The expert project managers gave the following statements:

I) Some external factors such as the complication of projects has increased to meet regulatory and legislative requirements in the industry.

II) Productivity is increasing lately because of improved design and equipment and training. In addition, the key is to align all sectors of the industry (finance, design, construction, maintenance, and operations) within a safety and productivity context, also to have clarity around all contributors to the project.

Q 19 Regarding the most significant changes that the project manager or the construction companies could do to improve construction productivity.

The expert project managers gave the following statements:

I. The Northern Territory Government should change the form of the contract to a more modern version.

II. The government should embrace the quality assurance philosophy and contractors need to embed more engineering capability in their organizations.

III. Also, governments need to better understand risk management practices so that risks are addressed proactively.

IV. The government needs the utility to close roads for a period of time i.e. make big decisions which may inconvenience some people for a short time, in order to gain improvements in productivity and reduce the project duration and it will reduce the overrun cost.

V. Develop an approach to ensure that the workforce is able to deliver for the design and construction entities.

VI. There is a need for third parties to manage their input within society's expectations of behaviour.

4 THE VIEWPOINTS OF THE EXPERTS FROM CONTRACTORS

Q 16 – Regarding the indication and any additional factors that the project managers consider significantly affect productivity in the building businesses.

Builders' experts concentrated on the following factors:

I) To enhance the work-rate on the building location: cultural, behaviour, training, experience, and work ethics.

II) Location of the site relevant to major centres, and time for goods/people to travel.

Q 17 – Regarding the level of industry productivity, has it changed over the last five years and if so, how and why?

The expert project managers gave the following statements:

I) Wet weather should be considered in scheduling in order to avoid unexpected delay for material delivery and eliminate non-productive time to keep the budget on track.

II) The communication between the project parties has improved using email, phone, mobile for texting etc. reduced the communication time, but on the other hand, constant change in work levels due to economic conditions makes it difficult to retain staff and provide training or apprenticeships.

III) Also, contractors have promoted accountability and responsibility from the management side and the project managers on the site from the other side.

Q 18 – With respect to the most significant changes that governments in Australia could do to improve construction productivity.

The expert project managers gave the following statements:

I) Construction companies should provide more incentives for training and apprentices for motivation.

II) Develop a fairer system of awarding projects as price is still too dominant in the decision process, i.e. the cheapest is not always the best or the best final price after variations and disputes.

III) Spend more time developing quality drawings and specifications using a baseline for minimal entry of drawings.

IV) Have a reward system for contractors that point out issues.

V) Problems with the documents during the tender period that are rewarded for raising problems early before they are built and need to be fixed on site.

VI) In addition, removal of the red tape for development applications and streamline the requirements for local councils to be uniform.

Q 19 Regarding the most significant changes that the project manager or the construction companies could do to improve construction productivity.

The expert project managers gave the following statements:

Promoting the design and construct type packages are becoming more desirable to clients, as they believe that the likelihood of variations is reduced, and we should promote this concept as a more viable option, and empowering employees and creating a positive environment, which leads to a higher morale, productivity and reduces turnover of staff and human resources issues.

6.12 CONCLUSION AND THE SIGNIFICANT CONTRIBUTION TO KNOWLEDGE

The building industry is a major contributor to GDP in the Australian economy and determines the development of the national financial position. It performs in both the independent and government sectors, and is involved in three major areas of work.

This research is based on a questionnaire survey. The survey consisted of two rounds. The first survey round was a general survey which reported on the rating given by experienced project managers in a variety of building companies. The second round was a Delphi validation survey. In the Delphi approach, analysis can include both qualitative and quantitative information. Qualitative information in the Delphi technique deals with unrestricted questions to canvass opinions in the first round. The redundancy procedures are to classify and reach the goal stage of general agreement and also smooth out any variation of opinions between panel members (Hasson & McKenna 2000).

In the Delphi survey of this research, a relative importance index (RII) was applied to rank the critical success aspects that influence the work rate of the building industry in Australia.

The first round survey, which identified 23 primary factors and 25 secondary aspects with substantial effects on the building productivity/work rate, has both confirmed that there are a few problems in the construction productivity in the Australian construction environment and investigated the main aspects impacting on building productivity in this environment. These aspects were rated concerning their RII as ranked by experienced project managers in the building industry. For example, rework was ranked number 1, incompetent supervisors number 2, incomplete drawings number 3, lack of materials number 4, work overload number 5, poor communication number 6, poor site conditions number 7, poor site layout number 8 and so on (Hughes & Thorpe 2014). These aspects were calculated and ranked with regard to RII in Table (4.10 a) and then discussed.

The Delphi validation survey was sent to a team of experts in the building industry. They were very experienced project managers with 15-plus years of experience in order to confirm the findings of the first round survey. The collected data from the Delphi survey respondent project managers was analysed and ranked according to RII and tabulated in Table 5.4. A comparison between the RII rankings for the two surveys was tabulated and explained in Table 6.5. The validation of the responses between the four groups of project managers (academics, consulting engineers, public works and contractors) were calculated and analysed in Table 6.2.

The Delphi survey as a qualitative survey with open-ended questions has identified new factors not considered before in two previous surveys. It covered some issues related to government regulations, councils, and construction unions, as explained previously in section 6.9 – Thematic calculating the replies of the Delphi second stage qualitative survey.

Now Chapter 7 concludes the study and offers some recommendations for further research.

CHAPTER 7
RESEARCH RECOMMENDATIONS AND CONCLUSION

7.1 INTRODUCTION

Construction is an essential industry in Australia. Its sales reached $327 billion, equal to 21 per cent of GDP (Department of Industry, Innovation and Science 2014) and its share value added up to 7.6 per cent of GDP.

Data and information collected from the Australian Bureau of Statistics helps to investigate and evaluate productivity size and value in the construction industry and its divisions; construction accounted for 35 per cent, civil engineering construction accounted for 23 per cent and construction services accounted for 43 per cent of the industry.

The term ‘productivity’ is used loosely in everyday language. The technical definition of productivity is “the measurable relation between the industry output and the workers and capital inputs.” In order to measure the output, the construction industry initiated the term ‘value added’, and for workers input the best measure is working hours. Australian construction workers’ productivity is extremely significant because it is one of the drivers of living standards.

Construction is an extremely constructive industry with a value added above the average of all other industries. Some divisions of the construction industry, for example, heavy and civil engineering are extremely constructive, creating productivity 53 per cent higher than the Australian average (Richardson 2014).

As at November 2011, the building industry hired 1,039,900 workers (Australian Bureau of Statistics 2011), making the construction industry the fourth largest industry in Australia.

In August 2014, the Australian Bureau of Statistics reported that the service division (65% of total GDP) governs Australia’s economy. So far, its economic achievement is established on the basis of large amounts of agricultural and mineral assets. The most significant and most progressive area of the economy is manufacturing, with mining contributing 13.5 per cent of GDP, manufacturing 11 per cent and construction 9.5 per cent; agriculture contributes the remaining 2 per cent of GDP.

This website – Australia GDP annual growth rate – provides actual values, historical data, forecasts, charts, statistics, economic calendars, and news (ABS Aug 2014).

Table 7.1 Australia GDP annual growth rate 1960–2014

Definite	Former	Topmost	minimum	Dates	Unit	Frequency
Three & a half	Two & 7/10	nine	(–)Three & 4/10	1960 To 2014	Percentage	Quarterly

Source: ABS August 2014

Researching and studying of the productivity of the construction industry provides observation of the industry influence on economic progress. This thesis addresses a questionnaire survey that required experienced building project managers in different building/construction institutions in south-east Queensland, Australia, to consider different aspects of the construction industry by ranking 32 initial factors that have influence on building productivity, which has indicated that there are a restricted numbers of critical factors affecting construction productivity in the Australian context (Chapter three), particularly with regard to the execution of building works. This research has also identified the critical aspects influencing the building work rate in Australia, which were ranked to have an average to extreme influence on construction productivity. These influences were ranked regarding their relative importance index (RII) from the project managers' viewpoints.

In general and from the literature survey, 32 factors were determined to be potential aspects affecting construction work rates globally (Objective one); however, in Australia the first questionnaire showed that three essential aspects: redo/rework, unskilled supervisors and unfinished drawings, are thought to cause a strong influence on building productivity (Hughes & Thorpe 2014). Three more aspects: work overburden, shortage of building components and poor communication, are considered to have an average to strong influence on the building work rate (Table 6.2). In addition, nine aspects that are more elementary are thought to cause an average influence on the building work rate. A mathematical calculation of the subordinate aspects, which were provided alongside the elementary aspects, was also undertaken. In particular, the aspect of incomplete drawing/unfinished designs was investigated in detail.

Regarding responses to the surveys for this research, it is therefore concluded that in Australia, and specifically in the state of Queensland, the group of project managers who responded to the questionnaire classified a few aspects which greatly impact on building productivity in this region (Objective two), and also recognised another 15 aspects with an average impact on the construction productivity in that region (Table 4.10 a). The other essential aspects of rework, unskilled supervisors, and unfinished drawings are likely to be associated with the architectural and project management procedures. These matters are hard to control in a situation in which subcontractors are employed broadly (causing complication in people management procedures). Nevertheless, actions such as expanding associations among the groups in the work agreement (for example, in relation to contracting), supervisor education, and communication enhancement and development among the groups to a contract could be taken to enhance productivity.

The primary goal of this thesis is investigating the present Australian circumstances, and the influence of a numbers of projects researching correlated aspects influencing building productivity that have been recognised as having substantial effects in the field of worldwide research, and reaching final results for the relative importance index (RII) for these aspects as ranked by qualified project managers in the area of building and structural engineering in Australia. In addition, previous studies (Enshassi et al. 2014; Olomolaiye & Ogunlana 2006; Larbi, Antwi & Olomolaiye 2003) had shown that there are some aspects (for example, shortage of Materials/building components and shortage of tools/devices and machinery) that have been ranked as aspects impacting on the building work rates elsewhere (Megha & Rajiv 2013; Cox & Hampson 1998). Rework is the main factor influencing the building work rate in the region in which this study was carried out, followed by unskilled supervisors, which might be correlated to hiring problems in a resilient market during the period of the study. Unfinished designs are likely to be rated strongly in both this research and other research (Tressel 2008).

The focus of this study is based on its comprehensive investigation and rating of aspects that have an impact on the construction productivity in the Australian context (Objective four), in which the statistical, geographical, architectural and economic circumstances vary from those areas in which other research has been carried out. In addition, it has concentrated on competent project managers in building and civil engineering. Their opinions are plausible in the framework of this research.

Many of these aspects happen because of administration failure, for example, unskilled project managers, and mismanagement. However, various suggestions were submitted with regards to developing the work rate by removing and eliminating the influence of the negative aspects. Improvement of an organization's work rate in Australia must focus in the present time on those areas where there is potential for improvement; this will make construction institutions more lucrative, also boosting the opportunity for success in the construction business, particularly in the present time when there is considerable competition between construction organizations because of the economic situation (Tressel 2008). If advancement in more companies' work rate could be aided, generally the building work rate in Australia will be enhanced. Therefore, considering this study as a base, future research should stress productivity/work-rate development.

The research outcomes signify that the essential aspects that are the most important influences on construction productivity are subdivided into two groups (Objective three). The first group is the primary factors, which have a severe effect, and the second group is the secondary factors, which have an average influence on the construction productivity, as follows:

First group: the primary factors (significant effects – from initial survey) ranked according to RII values:

Rank	Factor
1.	Rework
2.	Incompetent project managers and supervisors
3.	Incomplete drawings
4	Work overload

5. Poor communication
6. Lack of material
7 Poor site condition
7 A poor site layout
7 Overcrowding
7 Inspection delay
8 Absenteeism
8 Worker turnover
9 Accident
9 Tools/equipment breakdown
9 Lack of tools and equipment

The second group: the secondary factors (the moderating effects):

1. improper transfer of materials to work location
2. on-location conveyance problems
3. fluctuation in availability
4. improper material usage to specifications
5. improper material handling on site
6. excessive paperwork to request
7. unskilled drafters
8. unfinished location scrutiny
9. insufficient time allowed to drafters and insufficient presentation for action
10. site overcrowding
11. inadequate planning
12. misuse because of carelessness/destruction
13. improper material depot
14. incomplete data supplied to the architect and drafters
15. insufficient design reviews of certified designs and drafting
16. unrealistic design
17. shortage of funds for procurement

More studies are needed in order to examine in depth the 15 recognised primary aspects. Applying the Delphi technique for a number of expert professional project managers was conducted by using a questionnaire survey covering all the 15 primary factors and their effects on productivity in the Australian construction industry.

7.2 RECOMMENDATIONS FOR CONSTRUCTION COMPANIES

The present worldwide economic circumstances and their adverse influence on the building and infrastructure industry capital projects in developed and developing countries have made improvement in productivity essential. This thesis describes the conclusion of a research project, and presents the most critical aspects, which can improve construction productivity in the delivery of structural projects in Australia and other countries. This study has surveyed very experienced project managers from consulting organizations, academia, public works departments, and construction contractors to identify some recommendations and ideas for improving productivity in future construction projects. Industry recommendations for improving construction productivity are categorized into several major areas: labour skills and management, rework, project managers and supervisors' competence, constructability in engineering design, engineering management, communication skills, government influence, and modularization. The following are some suggestions for productivity improvement.

- Complicated drawings/designs and incomplete drawings must be clear and more clarification must be enforced in order to eliminate any misunderstanding between the construction team workers; these factors are very costly and time absorbing because of rework.
- Alcohol, drugs, blood and breath tests must be used randomly in the workplace and firm penalties must be enforced with guilty employees.
- Absenteeism could be minimised with the addition of suitable paid leave and some flexibility at workplaces, which most workplaces are doing now.
- Rework ranked #1 in the initial survey and in the validation survey; this is because of a lack of suitable skills in some tradespeople and carelessness resulting in a poor level of finish, which requires rectification and rework. The attitude of many tradespeople is "near enough is good enough". This attitude is also evident in some supervisors, which leads to costly defects at the end of the project. This matter could be tackled through experienced and competent

supervisors and project managers noticing poor work first then, carrying out the required rectification to avoid cost overruns and project delays.

In detail, the principles of better administration and devices are not truly entrenched in the current construction administration procedures. Accordingly, rework becomes an acceptable practice in the construction industry. Rework causes some serious problems such as delaying the project behind schedule, cost overruns, and frustration to the owner or proprietor. Although rework is considered a severe problem in construction and building industries, a few studies have dealt with that problem; for example, (Love, Mandal & Li 1997 a). People who are participating in the construction/building industry are not aware of the damage and the cost of rework. For example, the costs of the rework on two different projects under study were as follows: the first project 2.4% and the second project 3.3% of the entire project budget. Now is the time to develop construction and building procedures in order to improve the quality of works and labour performance on construction sites in order to minimise or eliminate rework.

Rework is a chronic problem in the construction industry in some countries and Australia is no exception; the cost of rework varies between 12 and 15 per cent of the entire project expenses (Neese & Ledbetter 1991); in architectural and internal activities of projects, the costs of rework could reach from 4 per cent to 12 per cent or an average of 8 per cent of the total expenses of the project budget (Taneja 1994).

Therefore, in order to minimise the expenses of rework in the building industry, the managers should be familiar with the factors causing that problem, and the building industry should enforce the changes in social and technological aspects (Love, Mandal & Li 1997 b).

A study by Sugiharto, Hampson and Mohamed (2001) in Indonesia but conducted at Queensland University of Technology, about the factors causing rework (conducted by an inquiry survey, face-to-face meetings, and direct site examinations) showed the factors are as follows:

- Insufficient supervision on the construction site
- Incompetent supervisors
- Shortage of skilled workers and tradespeople
- Incomplete designs and drawings
- Inappropriate construction procedures
- Shortage in devices and machinery
- Other factors such as changes to the design, changes by proprietors and poor site conditions.

Project managers realize that the above factors are related to each other; sometimes one factor can lead to another factor. For example, an incompetent supervisor who fails to use the right construction procedures would affect the rest of the project activities. In addition, insufficient supervision, shortage of skilled tradespeople and incompetent supervisors are the leading factors for rework and project delay.

In order to control rework, the site engineer should mark up and evaluate the amount of rework and its costs, then the project managers will handle the matter (approving /disapproving the quantity of works and the money needed to fix the problem). Problems accompanied by rework could be documented through the construction procedures and recorded on a daily basis by the project managers. From the daily record, the project managers will be able to examine the problems, how, why, when and where they happened; and estimate the cost of the rework and approve each case on its merits.

In brief, identifying the factors causing rework in the construction industry will help project managers to determine appropriate procedures to reduce or eliminate rework. In addition, human skills (trades people's and supervisors' skills and competence) are the essential means to achieve any successful construction project with minimum errors and rework.

The characteristics of the construction site supervision are precisely connected to the supervisors' standard of background and experience acquired from academic training and on-site practical work. All this has the power to reduce rework costs.

- Communication was ranked number 1 in the validation survey (Delphi Survey, Table #5.4) because communication plays a very important part in the daily work on construction sites. Therefore, studying the usefulness of communication in the
- construction industry will be worthwhile.

Useful communication on construction sites:

Useful communication is essential to the profitable finishing of any construction project. Effective communication can enhance group work and bring on higher project cooperation. Poor communication could cause confusion, misjudgement, delays, rework, and problems such as cost overruns.

Definition of communication

Communication is plainly the exchange of data for conveying information and effective communication includes being capable of conducting your information to be accepted by clients. Effective communication is a proficiency which can be developed with practice and training. The following are some suggestions in order to enhance communication effectiveness on construction sites:

Set up an understandable channel of communication. It is essential to decide a series of directions and instructions for communication on a construction project.

These are usually explained clearly in the work agreement documents and normally need the proprietor and the main contractor to communicate between two of them through the engineer. The engineer is in charge of communicating with the professional engineers (consultants) and the main contractor or the contracting firm, in addition, is accountable for communicating with the materials suppliers and subcontractors. The supervisors on a project are normally the main source of

contact with the principal contractor.

The work agreement documents, such as the design drawings, specifications, changing order forms and demands for information, represent the basis for all building/construction communication. It is essential that any explicit communication not included in the work agreement documents gains the right approval and any necessary changes to the timetable are recorded, and communicated through the right avenues.

Selecting the proper communication means

Daily communication varies all the time, both verbally and non-verbally, and the communication on construction sites is no different. The new technologies in the field of communication include texting, mobile phones, landlines, in-person contact, email, and the fax machine. On the other hand, on the construction site artisans and staff are communicating through clues, illustrations, hand signals, and conferences/meetings.

All the means of communication have advantages and disadvantages. Selecting the proper means of communication can accelerate and clarify the exchange of data/information. Occasionally an email is enough to achieve the purpose, while another matter may require a meeting of all the key personnel on the project. The changing orders and day-to-day reports are normally specified in the work agreement documents with their forms and presentation methods. For example, if communicating through email in writing is not worthwhile, then using the phone to call a meeting will be worthwhile.

Means of communication for a particular project and data exchange must be started at the beginning of the project and approved by all shareholders. If there is any change from the agreed means of communication, it will lead to confusion because the messages will be delivered to the wrong person and this will create a setback in the project (Makulsawatudom et al. 2004; Megha et al. 2013).

The communication on construction sites requires clarity and conciseness; make sure that the message is understood by the other staff and workers. It is not recommended to use in communications slang language, jargon or terms that are hard for other people to understand, but the data/message must be aimed at the targeted point. It should be very concise, short and as easy to read as possible.

Professionalism in written communication

The professional staff, for example, executives, project managers, supervisors, and superintendents, should communicate in formal language and manner during working hours, avoiding any emotional effects in the messages. If the writer is very emotional, it is better to put the message on hold for a while until their emotions settle; after this, any changes can be made before sending. If the message or the information is urgent, then read the message aloud to yourself or try to get a second opinion before sending it. Simplify the big pieces of data/ information into shorter and more concise paragraphs. Staff and tradespeople tend to browse lightly instead of reading messages/emails. Therefore simplifying the data or the information into smaller segments makes it easier to understand. Enhance writing by using numbering or bullet points with complex data/ information or when asking questions. In addition, record and document all the communication related to the work on the construction site for future use if there are any disputes or clarifications.

- Unskilled/Incompetent supervisors and project managers ranked number 2 in the initial survey (table # 4.10 a) and number 5 in the validation survey (table # 5.4). The difference between the two ranks may be due to how the two participating groups of project managers perceived the survey. A well-planned construction project allows for unforeseen circumstances such as job site weather conditions. Examples include tropical storms or hurricanes in warmer climates, along with heavy snow or ice storms in colder regions. Additionally, skilled project managers ensure that crews consistently have enough materials to complete their scheduled work. When project managers anticipate a need for heavy equipment, such as a crane or earth-moving machinery, they ensure the equipment's timely delivery.

  In addition, the character of the construction site supervision has a great effect on the total achievement and the capacity of construction projects. Incompetent supervision is the main cause of rework. Accordingly, professionally and practically experienced supervisors are necessary on all construction sites for minimising the quantity of rework due to building imperfections. Incompetent supervision leads to poor work planning, which will create a poor construction method and will affect the workers as follows: The goal of studying the supervisor competence factor is to solve the problem of rework, because rework has become a critical factor in the Australian building/construction industry, and to improve site productivity. In the present study, the data collected about incompetent supervisors from the validation survey for each group of participants was as follows:

a) The academics group ranked the issue number 1 with a RII of 0.88
b) The consulting group ranked the issue number 1 with a RII of 0.70
c) The public works group ranked the issue number 9 with a RII of 0.47
d) The construction group ranked the issue number 1 with a RII of 0.83

In general, the validation group and the project manager initial group were in broad agreement about this factor's importance. From these results, there is agreement between the academics, consulting group, and construction group. There is a major difference with the public works group ranking compared with the other three groups.

Many studies have been conducted to identify and understand the causes behind rework in the construction industry; the outcome of these studies could not decide until now all the main causes of rework except the incompetence of supervisors. They are also studying the accomplishments of the supervisors who are approved to handle the site supervision in a building project. The skills of the site supervisors have a great effect on the general achievement and effectiveness of building projects; and the skills of the supervisors determine their skilled communication with the staffs and the tradespeople plus their methods of running the daily program and directing the work on the building site.

The feedback from the project managers states that the lack of adequate training of supervisors has created an increase in building costs. The lack of skills to run the activities on the construction site, and poor communications with staff and workers are the significant factors leading to increased rework and costs to fix the rework, causing cost overruns of the project. In order to develop the skills of the staff, supervisors and tradespeople, construction organizations must run intensive and periodic formal training programs (Business Roundtable 1982). This formal training will enhance performance, develop supervisors' skills, and reduce rework, and thus it will increase and improve construction productivity.

- **CONSTRUCTION RISK MANAGEMENT**

The construction organizations in many countries (advanced, developed, and developing) around the world have started to pay more attention to the construction industry because it is extensively correlated with extreme risk and unpredictability due to the working surroundings. Therefore, many studies are needed in this area of constructions to investigate and examine the building risk factors and assess their effects on construction productivity; then creating smart solutions to eliminate or minimise these factors for the sake of the workers, proprietor, and productivity, and to deliver the construction project on time and within budget.

The studies in the area of construction/building risk management could be managed by using a questionnaire survey similar to the one used in this thesis (Chapter 4) and analysed using SPSS or another suitable program.

The results obtained should be validated by using a Delphi survey or other methods. There are many factors in construction risk; some of them will be mentioned here. For example, a severe risk is that contracting firms may go bankrupt due to project failure, also when working on a project in a remote area far from metropolitan areas.

The construction organizations should add the cost of risk management to the project estimation and quotation. In addition, construction firms must conduct some practical training programs for the staff and artisans on risk management in construction projects in order to minimise risk.

There are three recommended methods for reacting to the risk in construction projects as follows:

-Prevention: removing a particular risk, normally by removing the source. A particular risk can be removed, but not all risks.

– Alleviation: decreasing the chance of occurrence of any financial damage to the project.

– Recognition: of the results based on creating an alternative plan in case the expected risk factor occurs. There are four different issues for dealing with the unexpected (risks) in a building task, a) risk avoidance, b) risk reduction, c) risk retention, and finally d) risk transfer (Ahmed et al. 2008).

Therefore, construction organizations must hire specialised risk management companies or teams to release the risk responsibility to professionals for handling, or use a computer software package such as a risk package, which works with Microsoft Project and Excel.

In this study, from the principal survey and Delphi survey sent to a team of project managers and a group of experts in the building/construction industry, a number of risks involved in the building industry in Australia have been identified. These risks include for example: rework, accidents, incompetent supervisors etc. These three factors out of fifteen factors represent not only critical success factors in the construction industry but also risk factors against productivity.

- Lack of materials was ranked number 6 in the initial survey - see Table 4.10 (a), and 4 in the Delphi survey – see Table 5.4. Administer a materials provision timetable for every project. The timetable must include the time needed to deliver building components and the availability of components in the regional market.

Materials administration is an essential factor in any project preparation and authority. Materials use a large portion of any construction project's budget; therefore, wise materials management could reduce project expenses. There are some considerations in materials procurement: if the materials are purchased too early and stocked on site, this mean capital is locked up for a while and will incur some interest charges, and the materials could deteriorate or be stolen.

As an example, electrical components are usually stored in waterproof containers. On the other hand, extra costs will be created if materials required for some works are not ready for use. Therefore, project managers should secure a prompt stream of materials. Instructions for ordering construction material need to be considered at the beginning of the project in preparation and scheduling steps. The applicability of the construction components could affect the schedule in projects with a tight schedule: adequate time to get the required materials should be permitted. Sometimes, the contractors hire specific materials suppliers or shippers to get their materials fast and gain more time. Using a computer system to order the necessary materials will ease the problem of procurement because the computer will assure the consistency and completeness of the procurement procedures. Due to improved materials management, labour productivity has been improved because of the availability of construction materials and the reduction of workers' idle time. The expenses of obtaining and caring for a materials management system have to be distinguished; the purchase of such a system could be beneficial.

Many project proprietors goals are to complete the building projects as soon as possible to achieve a quick recovery of their invested capital. Therefore, many proprietors are using fast-track constructions in order to reduce the time and to eliminate any delays during project procedures. One of the main factors causing delays and time overruns is materials mismanagement on construction sites. The delays in materials delivery are a main cause of discrepancies in the project activities on site and on the delivery schedule. To make the program of materials management on any construction site productive, the project managers have to have integrated materials management procedures from the design stage to the stage of using the materials. Bell and Stukhart (1986) outlined materials management objectives that include a planning and materials department, dealer assessment and choice, buying, payment, transportation, material acquiring, storage and stock, and material dispersion. The mishandling and mismanagement of the materials on site during a construction procedure will affect the project budget, time and quality (Che et al. 1999).

The expense of materials management might extend from 30–80 per cent of total construction expenses (Proverbs, Holt & Love 1999). Similarly, around 60 per cent of the total working budgets of industrial organizations incorporate materials expenses (Dey 2001). Accordingly, there is an urgent need for competent materials management for controlling the productivity and expenses in building projects. Furthermore, some studies indicated that some factors are contributing to materials mismanagement in the building industry.

Zakeri et al. (1996) advised that misuse, shipping problems, mishandling at work, abuse of the specs, shortage of a perfect working plan, unsuitable materials transfer and extra paperwork all negatively influence materials management. Accordingly, Dey (2001) indicated that the normal factors connected to building components are:

- Acquiring materials ahead of time will require costs and deterioration.
- Receiving the required material late will cause workers' idle time and loss of productivity.
- Wrong materials can be lifted from planning and design plans.
- Continuous drawing changes.
- Distortion of the materials.
- Selecting the right contract for the right materials obtainment.
- Selecting the right supplier.
- Administering extra materials.

Many construction organizations are implementing and using ICT in materials management to control the materials on the construction site. ICT is used in materials administration cost-estimating procedures by using data collection software, for example, Microsoft Excel (Chancellor 2015; Howard & Sun 2004). Nowadays, the internet is in use for many purposes such as email and e-commerce (e-invoicing, payments and receipts for materials) (Chan et al. 2010; Harris & Mc Caffer 2001). Accordingly, there is a great use of computers in all kind of industry and construction but still there is a need to increase the use of schemes to enhance materials administration in construction businesses (Faniran, Oluwoye & Lenard 1998).

Many researchers have developed applications for this purpose; for example:

- Construction Materials Planning System (CMPS) (Wong & Norman 1997)
- Material Handling Equipment Selection Advisor (MHESA) (Chan 2002)
- Construction Materials Exchange (COME) (Kong & Li 2001)
- Bar-code system – for material storage application (Chen, Li & Wong 2002) etc.
- More storage area for materials to provide the site with required amounts of materials in a timely fashion.
- Keeping good vertical site access for cranes, hoists, lifts, pumps, ladders and stairs for managing vertical handling.
- Maintaining the work locations as well surfaced, formulated, clean, and tidy in order to reduce the soiling of materials.
- Safe admission for materials/plant consignment.
- Work overload ranked number 4 in the initial survey – See Table 4.10 a, and number 6 in the Delphi survey. This requires better pre-planning and resource levelling. This is primarily associated with planning the works so the amount of labour on site is at a constant level, rather than having peaks and troughs. Uncontrolled work overload can cause a serious problem to the staff and workers, such as stress. Job satisfaction and productivity will be increased if stress is minimised. The job stress could be decreased if the job is well matched with the artisans' capacity and ability. The construction organizations should adopt stress management procedures as part of their work policy. In addition, stress in construction work occurs when the individual feels that the job demands are exceeding their capacity and ability to perform the job, and if it accumulates, it will affect work achievement. There is stress caused by factors basic to the job, such as inadequate tangible working circumstances, work overload or tight schedules (Mills 2013).

Sapra and Saxena (2013) stated that, stress is not certainly a bad issue, but it depends on how to perceive it, but if the stress extends to the breaking point, the job performance will be zero, the workers will leave their employer, absenteeism will rise; it can also cause physical or mental breakdown or depression problem.

Mills (2013) stated that, stress in the construction industry is an increasing matter in some construction organisation because of increasing the workload, and decreasing the artisans and staff numbers and working on tight schedule and for less money.

Some working circumstances can create job stress such as worries about job loss, work overload, shortage of authority, very bad working conditions, very rigid working schedule. All these factors must be eliminated in order to eliminate the job stress because the severe stress on the job will have a severe impact on the productivity (Hanson 2013).

Sapra and Saxena's (2013) survey indicated the relationship between stress and productivity as follows:

a) Forty-two respondents stated that their productivity level would increase by 25 per cent if their stress is reduced.
b) Forty-four respondents stated that their productivity could increase by 30 to 45 per cent if their stress level is decreased.
c) Twenty-nine respondents indicated that their productivity would increase by 46 to 60 per cent with lower stress levels.

The construction professionals added that job stress has very negative effects on life such as sleeping difficulties, tension headaches and working under pressure. Employers must take the matter seriously, apply stress management programs and medical help, and alleviate the factors causing the stress.

- Poor site layout was ranked number 7 in the initial survey - see Table 4.10(a) and number 6 in the Delphi survey (Table 5.4): Construction firms must prepare an appropriate site for purchasing the building components for every project that make accessibility easy and near the construction site in order to save labour time for materials handling. Avoid unnecessary movement of people – poorly planned working environments cause staff to unnecessarily move around the workplace. Furthermore, poor site layout can lead to a loss of productivity. Workers have to walk or drive a long way to staff or lunch rooms, rest areas, lockers and washrooms, site entrances, and site exits. All these factors will have an impact on productivity. In addition, the construction site should be well equipped and prepared with lighting, signs, and caution tapes for safety and directions, etc.

- Worker turnover was ranked number 8 – see Table 4.10(a) - in the initial survey and number 5 in the Delphi survey (Table 5.4). It is important for each construction organization to apply an individual administration scale to motivate staff and labour confidence. Keep good relationships with workers and staff to let them feel that they are valuable to their company, and also let them share their opinions in decisions related to their work; for example, procedures development such as binding rectification to accomplishment; guaranteeing that the salary, other payments, security and working environment are all suitable. All these will boost construction productivity. On the other hand, the construction industry is suffering from a serious problem called workers turnover. This problem is in urgent need of more investigation to find out the essential factors in worker turnover, the impact of worker turnover on contracting firms' achievement and reasonable

  methods that will tackle the construction worker turnover problem.

  The suggested reasons for worker turnover are as follows:
  1) Poor salaries and fringe benefits
  2) Poor treatment of staffs/workers
  3) Lack of progress and publicity

  These factors and more are the critical causes of worker turnover, while racial or ethnic tensions, bullying and religious tensions also have impact on worker turnover. Worker turnover has two effects on the achievement of the construction organization, called direct costs and indirect costs; for example, the costs of bringing in new staff, training new workers, and reinstatement of former workers represent direct expenses and indirect costs include, for example, working overtime, an extra project load on the remaining workers.

Suggestions to solve the problem of worker turnover are as follows:

- paying competitive salaries, wages and good fringe benefits to the workers and staff
- decent treatment of the staff/workers
- award the honest hard workers and dedicated workers
- justice, affirmative action, appreciation for all the workers
- cultural harmony is necessary to reduce cultural tension.

Lack of tools and equipment was ranked number 9 on the standard survey and number 7 on the Delphi. The reason for these rankings is that the project managers were considering this item outside of their responsibility. Tools are essentially supplied to the workers employed in full-time employment. Casual tradespeople usually bring their own tools and so sometimes they take the provided tools by accident with their own tools. Sometimes machinery, devices, and equipment are not easily accessible for hiring. The availability and accessibility of equipment, tools, and machinery need improvement in order to increase construction productivity. Construction organizations should consider the condition of the building components and devices employed in the projects, where applying the right building components and devices in order to reduce the time used to complete the project and to avoid damaging the building components will assist not only in having good-quality work but also in enhancing the workers' productivity.

- **Tools and equipment breakdown**

This factor was ranked number 9 according to the first survey and number 9 in the validation survey. The reason for these rankings is that the project managers were considering this item outside of their responsibility. The most likely breakdowns occur in earth vibrators, water pumps, and other powered machinery. In general, the main cause of tools and machinery breakdowns are inappropriate services/maintenance and negligence/ carelessness of the preventive maintenance, especially if the machines and devices are old and exhausted from extensive use. Some machines are out of order because of the shortage of spare parts. It is essential to have a very good mechanical workshop with a machining shop with highly experienced mechanical engineer and mechanical staff to service tools and equipment. In addition, much attention should be paid to the age of all the tools and equipment.

OTHER IMPORTANT CONSIDERATIONS:

- Hiring or recruiting suitable staff to perform the right work and also using a project program approach (for example, computer-aided construction project administration) in every project to maximise the associated aspects, and to ensure that activities permit continuous project achievement, to minimise the workers' non-productive time and education activity must be altered to enhance capacity by applying project planning programs, for example, Microsoft Project. In addition, the education/training approach must include new and modern techniques in order to develop the construction work rate on the building site; increasing the numbers of technical institutions that concentrate on teaching building trades, for example, block work, formwork, painting, plastering, plumbing etc. in order to enhance and promote the capacity and skills of artisans who are working on building projects (Question 16 Delphi survey – responses from a public works expert).
- The government could free up the rigidity of labour agreements by minimising the role of unions in being a direct party to labour agreements and by allowing individual agreements (Question 18 Delphi survey – consulting engineer).
- Develop a fairer system of awarding projects as price is still too dominant in the decision process, i.e. the cheapest is not always the best or the best final price after variations and disputes, i.e. spend more time developing quality drawings and specifications using a baseline for minimal entry of drawings, have a reward system for contractors that point out issues, problems with the documents during the tender period that are rewarded for raising problems early before they are built and need to be fixed on site (Question 18 Delphi survey).

- Selecting the right contractor for the job should be on merit but not on the lowest price, such as the contractors' record of accomplishment in finishing projects on time, within budget, with the best engineering and constructions specifications and client satisfaction .
- The Northern Territory Government should change the form of the contract to a more modern version. Government should embrace the quality assurance philosophy. Contractors need to embed more engineering capability in their organizations (Question 18 Delphi survey).
- Invest in skills training by making higher education more affordable especially when it is employer-sponsored. Some project managers are engineers with no financial training, for example, but are tasked with managing multimillion-dollar contracts. Clearly, they will not get this from being on the job and need further education (Question 18 Delphi survey).
- The government should invest in infrastructure; provide incentives to tertiary institutions to deliver affordable training across all construction professions and trades; and financial incentives to construction firms to invest in apprentices, and provide a progressive salary scale. Remove red tape for development applications and streamline the requirements for local councils to be uniform (Question 18 Delphi survey).
- Design diversions: High-level construction managers who begin a project with a complete design, and experience a minimum of in-process design changes, will experience less downtime while they rework estimates and reallocate resources. In turn, on-the-job project managers and subcontractors have fewer barriers to increased worker productivity and commitment to invest in quality thoughtful design, which would flow into a sound financial, builds assets (Question 19 Delphi survey).
- Governments need to better understand risk management practices so that risks are addressed proactively. The government needs the utility to close roads for a periods of time i.e. make big decisions which may inconvenience some people for a short time, in order to gain improvements in productivity and reduce the project duration (Question 19 Delphi survey – public works expert).
- Devise a set of key performance indicators (KPIs) to suit the institution and benchmark KPIs against industry standards (Question 19 Delphi survey).

7.3 THE RESEARCH LIMITATIONS

There are a few limitations to this study; these limitations were recognized at the stage of progressing the questionnaire survey, data collection and the analysis stage as well. Despite the existence of these limitations, the research candidate was able to collect reliable information from the questionnaire survey. These limitations are:

- The information/data collection was done in very busy periods of the construction works; most of the construction managers, project managers, and construction experts were working on a very tight timetable and had no time to spend on the survey. This had an adverse effect on the questionnaire's response rate (almost 40%).
- Future research would extend the study more widely across entire Australia with a larger group of construction expert participants.
- Some information was collected from project records or new recruits because the construction manager or project manager had left their jobs for one reason or another.
- The first survey or standard questionnaire survey took almost one year to structure, send to the participants, and get their responses back. This caused too much delay for the study.
- The validation survey (Delphi survey) took almost eight months to construct, sent to the experts, and get their responses, which represented another delay for the study.
- Some respondents refused to answer the open-ended questions on the validation survey for one reason or another; this affected the overall survey.
- This study is limited to construction projects in the state of Queensland, Australia. Nevertheless, as an initial authentication, the type and protocol were based on the expertise in the vicinity of Queensland. The responses obtained from the survey participants stressed that these results could be used in many other countries with the same circumstances as Australia. This matter should be examined more and used in other countries surrounding Australia and similar in nature to Australia.
- This study is limited to the critical success factors mentioned previously in relation to the construction industry within the state of Queensland. The study is covering most of the critical success factors hindering the building projects. However,

communication, rework, supervisor competence, and other factors do represent critical factors in the building industry, as explained in this study. In addition, the study was based on a limited number of project managers where the response rate was almost 40%. More studies are needed to address in depth the 15 primary critical factors hindering construction productivity in Australia. The results of the survey completion and findings were verified and validated based on the validation (Delphi) survey.

- One way of testing the strength of concurrence among the four teams of the participants is that an interrelationship investigation like Spearman's Rank Correlation Coefficient can be completed, but in this case it could not be performed because the groups were very small (five persons in each group). Therefore, the relationship between the experts from the Delphi survey (academics, consultants, and public works and contractors teams) and the PMs from the first survey in relation to their agreement on the critical productivity factors has been undertaken by inspection to decide the strength of concurrence among the respondents.

The demographics questions revealed that the respondents' gender was in this survey mainly 100% male; the construction industry in the past was mainly male-dominated, but women have begun to be involved in many different aspects of the industry for the last few decades and are achieving at a very high level.

The Honourable Mick de Brenni, Minister for Housing and Public Works in a Media Statements dated 13 Feb. 2017 that Government delivers women into leadership roles especially in a general referee position and the Palaszczuk Government is making serious inroads into women's leadership in the construction industry. In the present, women are representing Twenty-three percent of the BDDRCs referees (De Brenni 2017). This is further progress on the Palaszczuk Government's target of 50% women on boards by 2020 in the Queensland.

- The survey revealed that most of the project managers, almost 50%, were over 50 years of age and almost 47.2% were in the 30-to-50 age bracket. In the construction industry, artisans usually start work aged between 15–20 years, while engineers start after graduation at around 23 years of age. Older project managers and artisans have more experience in the construction industry, which gave the survey fair information.

- It is well known traditionally in the construction industry that it takes about a decade for a qualified engineer to become a good project manager and 15 to 20 years for a non-qualified, inexperienced supervisor to achieve sufficient experience to become a project executive (US Bureau of Labour Statistics 2013). Accordingly, the survey shows that 80.55% of the project executives had acquired minimums of ten to over twenty years of experience. This experience is expected to make the questionnaire reliable.
- The survey addressed the PMs qualifications; within the construction industry. In this survey, the results were 38.88% qualified with master’s degrees, 41.66% with Bachelor’s degrees, and 19.44% with technical degrees. None held a doctorate. These percentages represent a very high standard for the project managers surveyed which supply the survey with reliable data, which will support the outcome of the survey results.
- Regarding the length of employment and type of work performed during that period in different construction disciplines such as residential, commercial, industrial, civil, infrastructure, and its general effect on construction productivity. It wills strength the survey’s data collected from the project managers. For example, in the residential area the percentage of the project managers’ experience was high, between 1 and 5 years (19.4% to 22.2%), but from 6 to 10 years the percentage was lower (16.7%). Project managers with 11 to 20 years of experience were 8.3% to 11.1% respectively, which is a quite low.

7.4 RESEARCH CONTRIBUTIONS

The construction industry is a main contributor to GDP in the Australian economy and plays a strong role in economic progress. Studying and knowing the work rates of the construction business provides a deep look into its influence on economic progress. The research, which addresses a survey of expert construction project managers in a group of construction companies in Australia who were asked to rank a number of aspects with the power to influence the construction productivity, has indicated the following two factors: first, it certifies that there are some construction productivity issues in the Australian construction industry and, second, it has investigated the main aspects influencing the construction productivity in this context, specifically with regards to carrying out the projects.

This research used a Delphi survey as a quantitative and qualitative validation survey to get the best results, as mentioned in section 6.11 (Objective five) – the conclusion in Chapter 6. Here is a part of that explanation.

The Delphi survey was sent to a team of experts in the building/construction business. They were very experienced project managers with 15-plus years of experience in the field of the construction industry, in order to confirm the findings of the first round survey. The collected data from the Delphi survey respondent project managers was analysed and ranked according to RII and tabulated in Table 5.4. A comparison between the RII rankings for the two surveys was tabulated and explained in Table 6.5 (Objective five). The validation of the responses between the four groups of project managers (academics, consulting engineers, public works, and contractors) was calculated and analysed in Table 6.2.

The Delphi survey as a qualitative survey for open-ended question has explored new factors not considered in previous surveys. It covered some issues related to government regulations, councils, and construction unions, as explained previously in section 6.9–Thematic calculating of the replies of the Delphi second round qualitative survey.

The contribution of this research is to provide and give information to improve productivity and reduce cost overruns in the construction industry in Australia through intensive research of the critical aspects in building/construction productivity.

The research has concentrated on finding the critical success factor and other factors hindering the progress of construction projects and causing cost overruns and delays in project delivery dates, even sometimes leading projects to fail.

These factors from the initial survey have been studied in depth in this thesis and in the published paper ‘A review of key enabling factors in construction industry productivity in Australia’ (Hughes & Thorpe 2014). This study will provide integrated knowledge to the building and construction business globally and in Australia in particular.

The main strength of this research, besides being the foundation and an essential pillar in investigating the relationships among the aspects specified in the study survey and the productivity problems in the building/construction industry, is that the data collected from the academics, public works, owners, engineers, and contractors has been analysed carefully and in some detail. Its results have been compared with the other data collected and analysed from experts responding in round two of a Delphi survey. All of this data has been employed to explore the most important aspects for enhancing productivity and project progress in Australia's building and construction industry Finally, this research is backed up with solid practical data (from the principal survey and the validation survey) as evidence to be used as a foundation for forthcoming study that examines the factors productivity problems in the building/construction business in Australia.

7.5 THE PROCESS USED TO DEVELOP THE RESEARCH QUESTIONS

Throughout this research, several methods were investigated to discover the form in which the research questions (see Section 1.5) are developed. The identification of disparities is one way, if not the most effective way, to formulate research questions from existing literature. The idea of identifying disparities is essentially searching for discrepancies in the literature and formulating a new and interesting question based upon those disparities. The new research question should cover the differences in the literature that were not previously covered. This process for identifying the gaps in the literature is discussed in Section 2.25 and is further developed in this section. It is based on a paper by Sandberg and Alvesson (2011)]

7.5.1 PINPOINT THE CRUCIAL GAPS, DISCREPANCY, AND DISPUTE IN THE APPROPRIATE LITERATURE

Research questions must be creative to engage with the key research issues. The essential question remains: How are contemporary analysis questions formulated from the literature? In Chapter Two of this research, a literature survey was undertaken to review a number of research papers. This research in turn led to creating the significant research question. Pinpointing the existing and various disparities between the literatures aided in the creation of advanced research investigations. The identification of discrepancies is not a consistent matter but diverges in how often the discrepancy has occurred and how complex the discrepancy is.

7.5.2 HOW THE PINPOINT OF THE CRUCIAL GAPS, IN DISCREPANCY AND DISPUTE LED TO CREATION OF RESEARCH QUESTION

In order to confirm the outcome of the literature survey in Chapter Two and to boost the idea of the productivity problems in the construction industry in Australia, a study was developed and a questionnaire survey was conducted. The survey was achieved on two rounds. The standard survey and the second round was a Delphi validation survey.

The Delphi survey was sent to a group of experts in the construction industry in order to confirm the findings of the standard survey. The collected data from the Delphi survey respondent were analysed and ranked according to RII and tabulated in Table 5.4. A comparison between the RII rankings for the two surveys was tabulated and explained in Table 6.6. The validation of the responses between the four groups of project managers (academics, consulting engineers, public works, and contractors) was calculated and analysed in Table 6.2. The results of the two surveys were validated by Kendall coefficient of concordance ‘w’ Table 6.7

From the above studies, the identification of these gaps inconsistencies and/or controversies led to the formulation of the thesis question that was formulated for the investigation. Therefore, the question was selected as a topic for this thesis in general and limited to the problem of the productivity, in particular, is ‘The main factors that promote successful innovation with productivity within the construction industry in Australia: the project manager’s perception an analysis’. On the other hand, the research did not explore other peripheral areas because it is not applicable to this study.

7.5.3 ADDRESSING THE THESIS OBJECTIVES

The selected question to this thesis in Section 7.5.2 led to branching out the investigation to the five research objectives listed in Section 1.3 and further discussed in Section 3.6. The process of identifying the gaps in research follows that of Table 2.15. The relationship of the identified gaps to the research objectives is in Table 7.2. This table is subdivided into four columns as follows:

1. Thesis objectives;
2. How this objective was approached (e.g. observation, deduction, etc.);
3. Major findings (including the reference to the main section/s of the thesis document where this is covered).
4. Limitations/Further work needed.

The process used to develop the research questions involved the identification of disparities and working upon those discrepancies to create contemporary questions. The creation of advanced research investigation stemmed from the identification of disparities. The literature survey from Chapter Two reviewed a number of researches, thus alleviating the creation of the significant research question. The crucial gaps were pinpointed and in order for the conclusion of the literature survey to be affirmed, the study was built.

The Delphi survey was required to approve the outcome of the standard survey. The finalised data from the Delphi survey was analysed and ranked according to RII and later tabulated in Table 5.4. From the survey, the identification of discrepancies and/or controversies led to the advanced research investigation. From these analysis' the thesis question was chosen as 'The main factors that promote successful innovation with productivity, within the construction industry', Finally, the question of the thesis led to the expansion of the investigation. These various five topics are explained in Table 7.2.

Table 7.2 Gaps Explanations

Number	Thesis objectives	How this objective was approached	Major finding	limitation / further work needed
First	To pinpoint the hindering aspects that presently continue in the construction/building business in Australia by uncovering the best practices prevailing and the complications influencing productivity achievement.)	Through a process of deduction	By investigation of the aspects influencing it, either positively or adversely. Gaining the benefit of the indicated aspects that positively alter construction productivity, and remove (or regulating) aspects that have an adverse influence will significantly enhance construction productivity (Hughes and Thorpe, 2014).	Future research would extend the study more widely across entire Australia with a larger group of construction expert participants.
Second	To decide the most compelling key barometer of building/construction productivity in Australia).	Through a process of observation	A methodical sense analysis approach was used to examine the effects of some aspects hindering building productivity. In addition, the senses assisted in studying the perceptions of the project managers on the aspects that influence achievement in the construction industry, for example, rework, work overload, absence of materials etc.	Some information was collected from project records or new recruits because the construction manager or project manager had left their jobs for one reason or another

Third	To classify the negative achievement aspects, which are most significant in hindering productivity success).	Through a process of deduction	The RII method is still in force to decide the most important element's accomplishment sign of the structure and productivity. The RII is calculated by the formula: RII = ∑ W / AxN (See the thesis page 89)	More work on the standard and Delphi surveys needs to done to explores more issues in the productivity of the construction industry. Also, to be sent to more project managers to collect more data for analysis to get an accurate result.
Fourth	To analyse, using a unanimity expert group, the greatest critical success aspect of the Australian building industry and to evaluate the degree of agreement/disagreement among project managers (using Delphi techniques) regarding the ranking of the relative importance index (RII).	Through a process of deduction	The degree of concurrence among project managers concerning the ratings of aspects was decided in agreement with the Kendall Coefficient of Agreement. The degree of concurrence could be decided by the following formula (Frimpong, Oluwoye and Crawford, 2003; Moore, McCabe, Duckworth, and Sclove, 2003):	

Fifth	To identify the cooperation among the ratings of consultant owners and contractor groups for RII).	Through a process of observation		

7.6 SUGGESTIONS FOR FUTURE RESEARCH

The following suggestions are made for future research and study of the critical success factors to eliminate cost overruns and project delivery delays in the construction industry. Researchers need to consider some of the following suggestions:

1) The methodology and the same study criteria could be applied to other countries.

2) Using consensus forming techniques permit the consolidation expert assessment to rank the critical success factors to enhance project achievement in the construction industry. The effect of ranking the critical success factors indicated how these could be used to examine the suitable procedure to enable any institution to improve project performance. More consideration for future policies and strategies proposed merging and enhancing the construction industry is an open alternative.

3) Future research would extend the study more widely across Australia with a larger group of construction expert participants.

4) Using the same research procedures to various procurement means, for example design and build, turnkey and so on, could be priceless for the construction industry to use a new way to contracting and contract award procedures, and will provide better control systems.

5) Some of this study's ideas could be used to focus on projects that have suffered greatly from critical factors.

6) This research idea could be applied specifically to any project that suffering significant delays, quality, work rate, and cost overrun. There is the possibility to advance a mathematical example ranking the success factors for the construction methods under different headings in a ranking order.

This research could be expanded by accumulating the assessments of specialist engineers, who could assist the investigators by supplying neutral information, because consulting engineers have wide experience in the construction and building industry. For example, they perform investigations and reporting

1) Full detailed design and preparation of contract documents, they are responsible for arranging contracts, they offer full assistance throughout the building and knowledge of works, authorise methods, and determine closing accounts. On the other hand, the main role of professional architects is to meet their commitments, and their salaries are received entirely from the project owner/customer.

2) More investigations are needed for creating and improving methods and ways to measure the construction productivity in the building industry.

3) The survey should be sent to project manager with more stable employment because in this survey some information was collected from project records or new recruits because the construction manager or project manager had left their jobs for one reason or another.

4) It is noticed from the demographic survey that the answer for some questions was strange such as the project manager's gender. The number of female on the construction site is zero and the male number is 100%. This goes back to the old days when the construction industry was male dominant. A few decades ago, some women entered the field of the construction works. The construction industry should encourage more women to participate in the industry by enforcing the safety issues on the site, justify the salaries, and run a training program on site and send the new hire to any educational institution such as TAFE College or Universities in order to get a qualification in the construction field. On the other hand, the construction industry should improve the image of the industry and eliminate the sexual harassment between females and males on the job.

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8) In the future studies and future survey, the open end questions should be reduce to minimum or eliminated altogether because in the current survey some respondents refused to answer the open-ended questions on the validation survey for some reasons; this affected the overall survey results.

9) Applying the consensus forming techniques permit the consolidation of the expert opinions to rank the critical success factors in order to enhance and develop the project performance in the building industry. The consequence of ranking the critical success factors demonstrated the way to search the process to help the government body to improve construction project performance.

10) There is a need for more in-depth study, additional investigations, and validation to strength the study findings in the area of the relationships between construction productivity and the critical success factors. In particular, the main aspects of redo/rework, unskilled supervisors, unfinished designs, and poor communication, which ranked number one in the Delphi second round survey, need more extensive and comprehensive study. The elementary aspects influencing the building work rate must be examined.

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APPENDICES

APPENDIX A

A.1 Initial Data Analysis

(The original data from the surveys is available from the author)

A.2 Data analysis of questionnaire responses using Statistical Package for Social Science (SPSS).

(The original data from the surveys is available from the author)

APPENDIX B THE MAIN QUESTIONNAIRE

Appendix B. 1 COVER LETTER

UNIVERSITY OF SOUTHERN QUEENSLAND (USQ)

FACULTY OF ENGINEERING AND SURVEYING
TOOWOOMBA, QUEENSLAND 4350, AUSTRALIA

Dr David Thorpe, Sr. Lecturer Phone (07) 3470 4532 - Fax (07) 3470 4241

August 6, 2010

Dear Project Manage

Mr. Rami Hughes is a Doctor of Philosophy student at the University of Southern Queensland (USQ), Queensland, Australia. He is undertaking research into the crucial factors that Promote Successful Innovation of the Productivity of the Construction Industry in Australia and the United States of America: the Project Manager Perception. As part of this research, he will be contacting project managers in large construction firms.

The objective is to establish the status of construction productivity practices. It is anticipated that the productivity practice of large firms will influence the entire construction industry in the future.

To have a successful study, your participation is needed in the completion of the enclosed survey. Please feel free to answer only those questions for which answers can be readily obtained. The survey is designed to be completed in a few minutes. Your responses will be kept confidential.

As an expression of our gratitude for your participation in this study, we will provide you with the summary findings of this research. This report will contain important information on various productivity practices identified in this study.
Thank you for your consideration.

Kind regards,
Dr. David Thorpe
Associate Professor, Faculty of Engineering and Surveying(USQ)

Enclosed: (1) Consent form
(2) Study at a glance
(3) Questionnaire

APPENDIX B. 2 CONSENT FORM

CONSENT FORM

I have read the information above and agree to take part in this study. I understand that my participation is completely voluntary, that I can decline to participate or withdraw at any time.

I understand that the results of the study may be reported in a journal article; however, neither my company, my organization nor I will be identified. I also understand that this consent form will be detached from the rest of the questionnaire. I declare that I am over 18 years of age, and I hereby give my consent to participate in this study. Please provide me with some best method of contact, whether this is email, mobile, landline telephone, or personal assistant
Thank you,

Company name..

Project manager name ………………………………………………………

Signature …………………………………………………………………

Date ……………………………………………………………..

Email……………………………………………………………………………

Phone...

Mobile #..

Fax #..

If you would like a copy of the final industry report and recommendations, please place an 'x' in the box. Yes ☐

Would you be willing for the Survey Administrator to give you a quick telephone call if any answers require clarification?" Yes ☐

APPENDIX B. 3 THE STUDY AT A GLANCE

STUDY AT A GLANCE

Factors affecting construction productivity in Australia have been highlighted in previous studies carried out by different authors. This confirms that the construction industry, in both Australia and the USA, has experienced similar problems to those of many other countries. The objectives of this study are to ascertain the project manager's perception of factors affecting construction productivity in Australia and the USA, and to confirm the results obtained from earlier research on the same issues. To do so, approximately two hundred project managers working in the construction industry in Australia and the USA will complete a structured questionnaire survey. The factors rated to have more than a moderate effect on productivity in both countries are insufficient materials, incomplete drawings, lack of tools and equipment, re-work, changes to orders, and tool and equipment breakdown.

This study investigates many productivity related issues in Australia, in comparison to USA, including productivity awareness among construction contractors, applicability of different productivity measurement methods, hindrances of productivity improvement programs, areas and functions which have high potential for productivity improvement, and the possibility of establishing construction productivity improvement programs

This study reveals the presence of productivity problems within the construction industry. The findings of this study further indicate that Cost Reporting and Control System (CRCS) is the most familiar, popular, and effective productivity measurement method, and that the lack of management support, trained personnel, and awareness are the most significant obstacles to Productivity Improvement Program. Of the Head Office responsibilities, planning and scheduling are found to provide the greatest potential for improving productivity, regardless of firm size. On site, management and equipment issues have most potential to improve productivity. Productivity Improvement Programs are found to be suitable for all projects, regardless of their characteristics.

APPENDIX B. 4 THE QUESTIONNAIRE

QUESTIONNAIRE

Q 1 What is your gender? Please tick applicable box.

a) Male ☐

b) Female ☐

Q 2 What is your age group? Please tick applicable box.

a) 20 to 30 ☐

b) 31 to 40 ☐

c) 41 to 50 ☐

d) over 50 ☐

Q 3 How many years experience do you have as a project manager? Please tick applicable box.

a) Less than 2 years ☐

b) 2 to 5 years ☐

c) 6 to 10 years ☐

d) 11 to 20 years ☐

e) More than 20 years ☐

Q 4 What is the highest level of education you have attained? Please tick applicable box.

a) Primary School ☐

b) Secondary School ☐

c) Technical /Vocational College ☐

d) University – Bachelors degree or lower ☐

e) University – higher degree ☐

Q 5 How many years do you have as project manager in the following areas?
Please tick appropriate box.

#	Type of Construction Industry	Number of years of experience					Remarks
		0 to 2 years	2 to 5 years	6 to 10 years	10 to 20 years	Over 20 years	
1	Residential						
2	Commercial						
3	Industrial						
4	Civil						
5	Other						

Q 6 How many years have you been a project manager in your current organization?
Please tick appropriate box.

a) Less than 2 years ☐

b) 2 – 5 years ☐

c) 6 - 10 years ☐

d) 11 – 20 years ☐

e) More than 20 years ☐

Q 7 How many project managers have left your current organization since you commenced employment with the organization? Please tick appropriate box.

a) 0 to 2 ☐

b) 3 to 5 ☐

c) 6 to 10 ☐

d) More than 10 ☐

Q 8 Why did you leave your previous job?
Please tick applicable box.

a) Left by own accord ☐

b) Employer Proposal ☐

c) This is my first job ☐

d) Other (Please specify)…………...……………………………………

Q 9 What type of contractor did you work for? Please tick applicable box.

a) General Contractor ☐

b) Sub-contractor ☐

c) Other (Please specify)………………………………………………

Q 10 What types of work does your organization do? Please tick applicable box.

a) Residential ☐

b) Commercial ☐

c) Industrial ☐

d) Civil ☐

e) Other..

Q 11 What is your opinion of the following aspects of your current organization? Please tick appropriate box.

	Opinion of	Ranks						Remarks
		Very Good	Good	Fair	Poor	Very Poor	No Opinion	
1	Employer							
2	Subordinate: - Efficiency - Friendliness - Team work - Communication - Meeting deadlines	.... … …	.... …..	.... …..	.... …..	.... …..	.... …… .	....

3	Working environment							
4	Level of payment							
5	Other (please specify)							

Q 12 How would you rate the effect of the following factors on productivity in the Australian construction industry using the following assessments?

	Factors	Rating					Remarks
		V. serious problem	Serious problem	Minor problem	No problem	No opinion	
1	Lack of Material						
2	Incomplete drawing						
3	Lack or breakdown of tools and Equipment						
4	Re-work / Incompetence						
5	Absenteeism / Worker turnover						
6	Work overload						
7	Poor site conditions, Overcrowding & layout						
8	Inspection delays						
9	Accidents						
10	Poor communication						
11	Other (please specify)						

Q 13 The ten most serious problems previously identified in the construction industries of most developed countries are materials, lazy workers, short construction season, funds, and so on. How would you rate the effect of the following factors on productivity in the Australian construction industry?

	Factors	Rating					Remarks
		V. serious problem	Serious problem	Minor problem	No problem	No opinion	
1	Shortage of funds						
2	Waste due to negligence/sabotage						
3	Improper materials storage						
4	Improper delivery of materials to site						
5	On-site transportation difficulties						
6	Fluctuation in availability						
7	Inadequate planning						
8	Improper material usage to specifications						
9	Improper material handling on site						
10	Excessive paper work for request						
11	Other (please specify)						

Q 14 How would you rate the effect of the incomplete drawing on the construction productivity in Australia using the following assessments?

	Factors	Rating					Remarks
		V. serious problem	Serious problem	Minor problem	No Problem	No opinion	
1	Designer provided insufficient detail						
2	Inadequate examination of approved drawing						
3	Impractical design						
4	Inexperienced draftsmen						
5	Incomplete site survey						
6	Inadequate time provided to draftsmen						
7	Inadequate proposal						
8	Other (lease specify)						

Q 15 How would you rate the effect of the lack of tools and equipment on the productivity in the construction industry in Australia using the following assessments?

	Factors	Rating					Remarks
		V. serious problem	Serious problem	Minor problem	No Problem	No opinion	
1	Improper maintenance						
2	Shortage of funds for procurement						
3	Inadequate planning						
4	Various sites under construction at the same time						
5	Improper application of tools/equipment						
6	Failure to report broken tools/equipment						
7	No organized storage						
8	Delays in inter-site loans						
9	Other (please specify)						

Q 16 Would you like to add any more information or comments?

APPENDIX C DELPHI TECHNIQUE PACKAGE

Appendix C. 1 COVER LETTER

UNIVERSITY OF SOUTHERN QUEENSLAND

The subject: FACTORS AFFECTING PRODUCTIVITY IN THE AUSTRALIAN CONSTRUCTION INDUSTRY: IMPROVING PRODUCTIVITY

Dear Expert Project Manager

Thank you for your interest in my research to develop a strategy for improving productivity in the Australian construction industry. You have been selected as a member of a panel of experts to participate in this round of the research survey and I value the unique contribution that you can make to this national study. Through your participation, a comprehensive description of your experience in the construction Industry will be obtained. It is through a qualitative and quantitative analysis of all survey participants that I hope to answer my research question and identify approaches to improve industry productivity.

How can productivity in the Australian construction industry be improved?

Through your participation and professional experience, I hope to formulate a strategy and a set of recommendations. You will be asked for opinions based on experience gained within your professional life to best approach the various problems I am investigating. I am seeking solutions and strategies you think will be appropriate to avoid low productivity and improve construction productivity in Australia.

All the information you provide will be strictly confidential and will only be used for academic research. All comments and responses are kept anonymous.

I value your participation and thank you for the commitment of time, energy and effort to this important area of research. If you have any further questions, please feel free to contact me at the addresses below.

Thank you,

Kind regards,
xxxxxxxxxxxx

Appendix C. 2 CONSENT FORM

CONSENT FORM

I have read the information above and agree to take part in this study. I understand that my participation is completely voluntary, that I can decline to participate or withdraw at any time.

I understand that the results of the study may be reported in a journal article; however, neither my company, my organization nor I will be identified. I also understand that this consent form will be detached from the rest of the questionnaire. I declare that I am over 18 years of age, and I hereby give my consent to participate in this study. Please provide me with some best method of contact, whether this is email, mobile, landline telephone, or personal assistant

Thank you,

Company name...

Project manager name ………………………………………………………

Signature ……………………………………………………………..........

Date ………………………………………………………….........................

Email……………………………………………………………………..

Phone...

Mobile #..

Fax #..

If you would like a copy of the final industry report and recommendations, please place an 'x' in the box. Yes ☐

Would you be willing for the Survey Administrator to give you a quick telephone call if any answers require clarification? Yes ☐

Appendix C. 3 STUDY AT A GLANCE

STUDY AT A GLANCE

Factors affecting construction productivity in Australia have been carried out by different researchers. This confirms that the construction industry in Australia has the scope for improved productivity to the potential benefit of industry and the nation. The objectives of this study are to ascertain the project manager's perception of factors affecting construction productivity in Australia, and to identify if there has been any change from the results obtained from previous research on similar issues.

By undertaking a study on the effects of a range of project execution related factors affecting construction productivity, it will be possible to come to conclusions about the relative importance of these factors in both building and civil engineering aspects of construction in Queensland, Australia. This investigation is expected to lead to the development of potential strategies to minimize the effect of those factors that will be assessed by this research to have the greatest potential effect on construction productivity. A structured framework for improving construction productivity in the Australian context is anticipated to be the main outcome from this study.

In this research, the Delphi technique is being used because its unique strengths, which relies on a structured, yet indirect, approach that quickly and efficiently elicits responses relating to group learning and forecasting from experts who bring knowledge, authority, and insight to the problem, while simultaneously promoting learning among panel members.

Appendix C. 4 – DELPHI TECHNIQUE (EXPERT'S OPINION ON THE SURVEY RESULTS)

Please indicate, by using the following scale and Circling or Highlighting the appropriate number, the level of IMPACT you give to each issue or attribute. Then, please indicate the FREQUENCY with which each issue or attributes actually occur, based on your experience within the industry. (The Impact Scale: 0 = No impact <-> 10 = Critical. The Frequency Scale: 0 = Not at all <-> 10 = Extremely high).

Factors Impacting Construction Productivity	The impact of these factors on construction productivity	Frequency (how often do these issues or attributes occur)	Comments / Causes
1) Rework: Correcting of defective, failed, or non-conforming item, during or after the inspection. Rework includes all follow-on efforts such as disassembly, repair, replacement & reassembly	0 1 2 3 4 5 6 7 8 9 10	0 1 2 3 4 5 6 7 8 9 10	
2) Incompetent supervisor : a person who is not possessing the necessary ability, skill, etc. To do or carry out a project; incapable to make a decision.	0 1 2 3 4 5 6 7 8 9 10	0 1 2 3 4 5 6 7 8 9 10	
3) Incomplete drawing: is the drawing without insufficient details, dimensions, misprinted and not enough specifications. Without complete drawing it will be difficult for a professional quantity surveyor to prepare a good specification and Bill of quantities for the contract	0 1 2 3 4 5 6 7 8 9 10	0 1 2 3 4 5 6 7 8 9 10	

projects, and result in cost overruns as a result of under-estimation and re-measurements.			
4) Lack of material: Materials are necessary for the construction process. In addition, since project activities are usually interrelated, if materials are short for a particular activity, this could affect other project activities.	0 1 2 3 4 5 6 7 8 9 10	0 1 2 3 4 5 6 7 8 9 10	
5) Work overload: Extended workweek schedules (Work overload) are sometimes used instead of larger crews, either to speed up construction work or to attract more trades to a labour-deficient area. Working 7 days per week without holiday has a high negative effect on labour productivity.	0 1 2 3 4 5 6 7 8 9 10	0 1 2 3 4 5 6 7 8 9 10	
6) Poor communication: Since there are many parties involved in the project (Client, Consultant, contractor, subcontractors). The communication between the parties is very crucial for the success of the project . Proper communication channels between the various parties must be established during the planning stage. Any problem with	0 1 2 3 4 5 6 7 8 9 10	0 1 2 3 4 5 6 7 8 9 10	

communication can lead to severs misunderstanding and therefore, delays in the execution of the project.			
7) Poor site conditions: The effects of the poor site conditions vary from site to site and may lead to working difficulties and unsafe working conditions; Consequently, accidents may occur, which cause delay. Poor site preparation is one of the causes of an unsafe working condition and it affect the productivity on site.	0 1 2 3 4 5 6 7 8 9 10	0 1 2 3 4 5 6 7 8 9 10	
8) A poor site layout: poor site layout causes material delay and it is the responsibility of management. It is a crucial project that has a significant impact on construction cost, productivity, and safety.	0 1 2 3 4 5 6 7 8 9 10	0 1 2 3 4 5 6 7 8 9 10	
9) Overcrowding: Overcrowding is the increase of all labour types within a given construction work area. Overcrowding uses the percent increase of all trades without specifying which crafts are within the work area.	0 1 2 3 4 5 6 7 8 9 10	0 1 2 3 4 5 6 7 8 9 10	
10) Inspection delay: Inspection delay may delay job progress, contributes to delays in work activities and for jobs on the critical path.	0 1 2 3 4 5 6 7 8 9 10	0 1 2 3 4 5 6 7 8 9 10	

11) Absenteeism: Is “chronic, unexcused, and excessive absences that adversely affect a construction project.	0 1 2 3 4 5 6 7 8 9 10	0 1 2 3 4 5 6 7 8 9 10	
12) Worker turnover: The number of employees hired to replace those who left or were fired during a 12-month period. In human resources terms, employee turnover refers to the rate at which employees leave jobs in a company and are replaced by new hires.	0 1 2 3 4 5 6 7 8 9 10	0 1 2 3 4 5 6 7 8 9 10	
13) Accident/Tools/equip: There are a number of types of accidents such as: Accidents leading to worker's death and it will result in stopping the work a number of days. Accidents that cause an injured labourer and small accidents that result from nail and steel Wires; all kinds of accidents will affect productivity with a certain degree	0 1 2 3 4 5 6 7 8 9 10	0 1 2 3 4 5 6 7 8 9 10	
14) Breakdown: Fail to report tools and equipment breakdown can cause the work to slow down and cannot be progressive or it can be done to an inadequate quality standard. It could have a crucial effect on construction productivity,	0 1 2 3 4 5 6 7 8 9 10	0 1 2 3 4 5 6 7 8 9 10	

15) Lack of tools &equipment: If there is a lack of equipment and/or tools, productivity will decrease. On the other hand, lack of proper tools and equipment could have a crucial effect on productivity, since, without efficient application of tools and equipment, work cannot be progressive or is done to an inadequate quality standard.	0 1 2 3 4 5 6 7 8 9 10	0 1 2 3 4 5 6 7 8 9 10	
16) Please indicate any additional factors that you consider significantly affect productivity in the construction industry 17) Do you consider that the level of industry productivity has changed over the last 5 years and if so, how and why? 18) What are the most significant changes that Governments in Australia could do improve construction productivity? 19) What are the most significant changes that you or your company could do to improve construction productivity?			

APPENDIX D DELPHI SURVEY QUALITATIVE RESPONSES

APPENDIX D.1 Q16 Please indicates any additional factors that you consider significantly affect productivity in the construction industry.

Respondents & their group	Comments
A (USQ)	No comments
B (USQ)	Market economic conditions impacting on availability of skilled tradesmen.
C (USQ)	a) Unnecessary movement of materials - materials delivered to site and not placed in a correct location intended for final assembly. b) Unnecessary movement of people - poorly planned working environment causing staff to unnecessarily move around the work place. c) Overproduction – example: excess concrete or mortar. d) Waiting – waiting for materials to be delivered to site or for one actively to be completed prior to commencing of second activity.
D (USQ)	Industrial relations - union sector anomalies generated by economic stimulus or retardation. Regulatory planning and approvals plus headwork changes may inhibit some development. For QLD the lack of daylight saving can cause issues for some contractors/contracts.
E (USQ)	A general lack of suitable skills in some trades and carelessness results in a poor level of finish. Therefore this requires rectification and re-works. I find that the attitude of many tradespeople is “near enough is good enough”. This attitude is also evident in some supervisors, which leads to costly defects at the end of the project.
F (Consultant)	Poor replanning.
G (Consultant)	No comments.
H (Consultant)	Most of the items that rated highly can be attributed to three factors. 1 – Poor planning. This is due to a couple of factors, mainly lack of skill or knowledge in how to plan work properly and lack of experience. 2 – Accountability has been the buzzword around the industry for a few years now but the reality is still that many projects have unclear or

	undefined accountability structure, which leads to no one being accountable for anything. 3 – Performance management has been, and will always be poorly done. It is easy to be critical behind closed doors but a lot harder to actually confront people about poor performance especially at an early stage when changes can be made.
I (Consultant)	Lack of integration between design, procurement and construction functions, leading to less than optimal construction/fabrication methodologies being adopted and more rework during construction. This is usually accompanied by lack of detailed planning. In many cases clients separate design from construction in the belief that they can obtain a more transparent competitive tendering process to drive this. This gets confused for efficiency. Lack of depth in the Australian manufacturing industry means we rely on overseas supply. Australia is a minor market for many overseas suppliers and manufacturers, and therefore the service and timing to obtain construction inputs is often a factor in inefficiency of delivery.
J (Consultant)	No response.
K (Public works)	Selecting skilled labour, and abandonment of apprenticeships, cadetships by the government and industry to save costs. It causes loss of skills transfer.
L (Public works)	Schedule and planning of the works. Empowering people to make timely decisions. Risk management, contingency plans. Providing sufficient number of skilled resources.
M (Public works)	As can be seen from newspaper reports the impact of third parties on the project can be important. The mitigation is likely to be aligned to ensuring behaviour is managed within society's accepted norms. The newspaper reports refer to earlier investigations, which are likely to have recommendations, which would add value to this research.
N (Public works)	No response.
O (Public works)	No response.
P (Contractors)	Cultural, behaviour, training, experience, work ethics.

Q (Contractors)	Location of the site relevant to major centres, and time for goods/people to travel.
R (Contractors)	Wet weather (civil).
S (Contractors)	No response.
T (Contractors)	No response.

Appendix D. 2

Q17 Do you consider that the level of industry productivity has changed over the last 5 years and if so, how and why?

Respondents & their group	Comments
A (USQ)	No comments.
B (USQ)	Increased level of tertiary-trained skilled principal contractor personnel has increased the efficiency & productivity of the build.
C (USQ)	No comments.
D (USQ)	Generally, I believe the industry has become more efficient. The skill of the construction site managers and project manager has generally improved and there is more logic and methodology to construction programming than previously. Contractors' availability and pricing has been volatile on the back of the 2009 GFC and the resource draw towards the mining and gas sectors.
E (USQ)	You would expect that the increase in technologies and with better work practices that productivity would increase. I believe though with the continuation of workplace health and safety requirements, that productivity is stifled to a point where we have become less productive.
F (Consultant)	No, I do not believe it has changed.
G (Consultant)	No comments.
H (Consultant)	Do you consider that the level of industry productivity has changed over the last 5 years and if so, how and why? The level of productivity produced vs. the wages earned has certainly decreased. A sense of entitlement clearly exists within the industry.
I (Consultant)	Not significantly, other than to notice that there is an increasing burden of documentation required by clients, which increases costs for construction and increases risks for the constructor.
J (Consultant)	No response.
K (Public Works)	Yes, there are a lot better tools available specifically designed for the job. There are better materials available that are easier to use and give

	better performance. Material is often factory-assembled which reduces site time and limits exposure to weather conditions which damage the materials. There is a better understanding of modern construction techniques, which give improved efficiency, e.g. slip for misty, concrete piling techniques.
L (Public Works)	Yes, however the complication of projects has increased to meet regulatory and legislative requirements.
M (Public Works)	Increased by improved design and equipment and training. The key is to align all sectors of the industry (finance, design, construction, maintenance and operations) within a safety and productivity context. The key is to have clarity around all contributors to the project.
N(Public Works)	No response.
O (Public Works)	No response.
P (Contractors)	Yes, affluence.
Q (Contractors)	Communication has improved using email/phone/text etc. Constant change in work levels due to economic conditions makes it difficult to retain staff and provide training or apprenticeships.
R (Contractors)	Yes, due to smaller margins and economic outlooks companies must run more productively to be profitable.
S (Contractors)	Yes, due to smaller margins and economic outlooks companies must run more productively to be profitable.

Appendix D. 3

Q 18 What are the most significant changes that governments in Australia could do improve construction productivity?

Respondents & their group	Comments
A (USQ)	No comments.
B (USQ)	Invest in infrastructure; incentive tertiary institutions to delivery training (affordable) across all construction professions and trades; financial incentives to construction firms to invest in apprentices, plus provide a progressive salary scale.
C (USQ)	To form a working group similar to the construction excellence in the UK with the aim of driving change in the construction industry. The objective is to improve industry performance in order to produce a better and more efficient built environment across all sectors and within the supply chain.
D (USQ)	N/A.
E (USQ)	Relax OH&S requirements and work with industry to develop solutions that are more workable.
F (Consultant)	Removal of unions. A recent example over the Easter holiday period the union workers all had EBA rostered days off. This created poor productivity last week, not being able to operate the tower crane etc. Despite these being rostered days off many of the union workers wanted to work, as they had no leave entitlements up their sleeves. Despite this, they were still not allowed to work because of the union.
G (Consultant)	No comments.
H (Consultant)	What are the most significant changes that the governments in Australia could do to improve construction productivity? Investment in skills training by making higher education more affordable especially when it is employer sponsored. We have project managers that are engineers with no financial training for example, but are projected with managing multimillion-dollar contracts. Clearly, they will not get this from being on the job and need further education.
I (Consultant)	I think the biggest change would be for clients to be willing to adopt more collaborative/incentivised construction contract models, rather than the more and more onerous commercial penalties and

	documentation requirements that predominate at present. The government could free up the rigidity of labour agreements by minimising the role of unions being a direct party to labour agreements and by allowing individual agreements.
J (Consultant)	No response.
K (Public works)	The Northern Territory Government should change the form of the contract to a more modern version. Government should embrace the quality assurance philosophy. Contractors need to embed more engineering capability in their organizations.
L (Public works)	Governments need to better understand risk management practices so that risks are addressed proactively. The government needs the utility to close roads for a periods of time i.e. make big decisions which may inconvenience to some people for a short time, in order to gain improvements in productivity and reduce the project duration.
M (Public works)	Develop an approach to ensure that the workforce is able to be to deliver for the design and construction entities. There is a need for third parties to manage their input within society's expectations of behaviour.
N (Public works)	No response.
O (Public works)	No response.
P (Contractors)	Promote accountability and responsibility.
Q (Contractors)	Provide more incentives for training/apprentices. Develop a fairer system of awarding projects as price is still too dominant in the decision process, i.e. the cheapest is not always the best or the best final price after variations and disputes, i.e. spend more time developing quality drawings and specifications using a baseline for minimal entry of drawings, have a reward system for contractors that point out issues, problems with the documents during the tender period that are rewarded for raising problems early before they are built and need to be fixed onsite.
R (Contractors)	Remove red tape for development applications and streamline the requirements for local councils to be uniform.
S (Contractors)	No response.
T (Contractors)	No response.

Appendix D.4

Q19 What are the most significant changes that you or your company could do to improve construction productivity?

Respondents & their group	Comments
A (USQ)	No comments.
B (USQ)	Commitment to invest in quality thoughtful design, which would flow into a sound financial, builds assets.
C (USQ)	Devise a set of KPIs to suit the institution and benchmark KPIs against industry standards.
D (USQ)	In our institution, we endeavour to provide the most complete design possible including all client stakeholder input at the earliest stage. In our experience, most delays arise from the design and approvals stage, rather than post detail design approval. Investing the time up front is always worth doing. In terms of the construction phase, we engage independent project managers and quantity surveyors to oversee the larger projects. Internal staff provides the client side project management and oversight of the overall project. This works well and we consciously keep a close relationship with the contractor and the service providers described earlier. Our approach is non-adversarial and we seek to create an excitement and engagement from all parties associated with our project. If there is a passion then projects tend to go more smoothly. We also, manage local site factors in order to minimise description or interruption of the contract and this can be challenging on the institution.
E (USQ)	To streamline productivity we must endeavour to provide the best documentation possible and ensure that the workplace readily accessible. Unfortunately there are factors which limit these including imprecise OH&S requirements to the point where, if these were the controlling element, our productivity would halve. Often I believe that those who work in OH&S have no real idea of the practical implications of their role.

F (Consultant)	Better project pre-planning and resource levelling. This is primarily associated with planning the works so the amount of labour on site is at a constant level rather than having peaks and troughs.
G (Consultant)	No comments.
H (Consultant)	Have a structured approach to up-skilling people, make the performance management process simpler, and improve planning especially around sourcing senior managers for large projects.
I (Consultant)	No response
J (Consultant)	No response
K(Public works)	Use more alliance contracts.
L (Public works)	Develop an enthusiasm for the business case to consider all risks and in particular develop an understanding that a "firm but fair" approaching to contracting brings benefits to client, designer, contractor, maintenance and operator. Recommended because this aligns all to how to deliver the best value and efficient and safe operation without excessive is transfer to parties' unable to carry or price the risk.
M (Public works)	No response.
N (Public works)	No response.
O (Public works)	No response.
P (Contractors)	Increase effective training and mentoring programs.
Q (Contractors)	We have been finding that design and construct type packages are becoming more desirable to clients, as they believe that the likely hood of variations is reduced, and we should promote this concept more as a viable option.
R (Contractors)	By empowering employees and creating a positive environment, which leads to a higher morale, productivity and reduces turnover of staff and HR issues.
S (Contractors)	No response.
T (Contractors)	No response.