CRITICAL SUCCESS FACTORS OF PROJECT MANAGEMENT FOR BRUNEI CONSTRUCTION PROJECTS: IMPROVING PROJECT PERFORMANCE

Rohaniyati Salleh

A thesis submitted in partial fulfilment of the requirement for the degree of Doctor of Philosophy

Principal Supervisor:
Professor Stephen Kajewski

Associate Supervisor:
Professor Jay Yang

School of Urban Development
Faculty of Built Environment and Engineering
Queensland University of Technology
2009

STATEMENT OF ORIGINAL AUTHORSHIP

DECLARATION

The work contained in this thesis has not been previously submitted for a degree or diploma at any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signed: _________________

Date: _________________

This research is dedicated to all the people who inspired, supported and encouraged me

"To my late father, late sisters and late brother, May Allah have mercy on them"

"To my mother, thank you for her love and support"

"To my husband, thank you for his inexhaustible support and encouragement"

"To my brothers and sisters, thank you for their continuous support"

"To my children, I hope this will inspire them to pursue their education and lead successful lives"

"To my friends and colleagues, thank you, thank you and thank you"

ACKNOWLEDGEMENT

These acknowledgements attempt to thank people who in some way supported, guided, and encouraged me along the way to completing this dissertation. I would like to express my sincere gratitude to the following people. Without their assistance, encouragement, suggestions and commitment this dissertation would not have been a reality.

Firstly, from the depth of my heart I would like to express sincere gratitude and appreciation to my principal supervisor Professor Stephen Kajewski for his continued support, generous academic advice, discussions, suggestions, close attention, encouragement and his incredible understanding and capability to initiate guidelines without being overbearing. Also I would like to thank my associate supervisor Professor Jay Yang, for his comments and support. As well, I would like to thank all the staff in the School of Urban and Development, Faculty of Built Environment and Engineering and Queensland University of Technology for their most welcoming support and friendly environment.

I would like also to express gratitude to all my friends and colleagues in Brunei for their enormous help in collecting the surveys and their participation in the questionnaires. Sincere gratitude and appreciation goes to all owners, contractors and engineers who participated in this research. A special thanks to the panel of experts for their contribution and valuable opinion.

Finally, to my family, a very special thank you for all their sacrifices, patience, love and support throughout my research studies.

ABSTRACT

The problem of delays in the construction industry is a global phenomenon and the construction industry in Brunei Darussalam is no exception. The goal of all parties involved in construction projects – owners, contractors, engineers and consultants in either the public or private sector is to successfully complete the project on schedule, within planned budget, with the highest quality and in the safest manner. Construction projects are frequently influenced by either success factors that help project parties reach their goal as planned, or delay factors that stifle or postpone project completion.

The purpose of this research is to identify success and delay factors which can help project parties reach their intended goals with greater efficiency. This research extracted seven of the most important success factors according to the literature and seven of the most important delay factors identified by project parties, and then examined correlations between them to determine which were the most influential in preventing project delays.

This research uses a comprehensive literature review to design and conduct a survey to investigate success and delay factors and then obtain a consensus of expert opinion using the Delphi methodology to rank the most needed critical success factors for Brunei construction projects. A specific survey was distributed to owners, contractors and engineers to examine the most critical delay factors. A general survey was distributed to examine the correlation between the identified delay factors and the seven most important critical success factors selected. A consensus of expert opinion using the Delphi methodology was used to rank the most needed critical success factors for Brunei building construction.

Data was collected and evaluated by statistical methods to identify the most significant causes of delay and to measure the strength and direction of the relationship between critical success factors and delay factors in order to examine project parties' evaluation of projects' critical success and delay factors, and to evaluate the influence of critical success factors on critical delay factors.

A relative importance index has been used to determine the relative importance of the various causes of delays. A one and two-way analysis of variance (ANOVA) has been used to examine how the group or groups evaluated the influence of the critical success factors in avoiding or preventing each of the delay factors, and which success factors were perceived as most influential in avoiding or preventing critical delay factors. Finally the Delphi method, using consensus from an expert panel, was employed to identify the seven most critical success factors used to avoid the delay factors, and thereby improve project performance.

CONTENTS

STATEMENT OF ORIGINAL AUTHORSHIP **i**

ABSTRACT **iv**

CONTENTS **v**

LIST OF TABLES **xviii**

LIST OF FIGURES **xxiv**

CHAPTER 1 INTRODUCTION **1**

1.1 Background to the research **1**

1.2 Research Objectives **3**

1.3 Research Questions **4**

1.4 Justification of the research **6**

1.5 Research Methodology **7**

1.6 Outline of the Research **7**

CHAPTER 2 OVERVIEW OF THE CONSTRUCTION INDUSTRY **10**

2.1 Construction Industry in Developing Countries **10**

2.2 Difficulties faced by Construction Industries in Developing Countries. **11**

2.3 Brunei Construction Industry **16**

2.3.1 Introduction to Brunei **16**

2.3.2 Brunei Construction Industry **19**

2.4 Construction Classification: Brunei Construction Industry **26**

2.5 Project Parties: Brunei Construction Projects **27**

2.6 Project Development: Brunei Construction Industry **28**

2.7 Common problems: Brunei construction Industry **29**

2.7.1 Owners **29**

2.7.2 Designers **29**

2.7.3 Consultants **30**

2.7.4 Contractors **31**

2.7.5 Construction resource suppliers **31**

2.7.6 Other sources **32**

CHAPTER 3 LITERATURE REVIEW INTO PROJECT SUCCESS FACTORS AND DELAY FACTORS **35**

3.1 Delay factors **35**

3.1.1 Causes of Delay in the Construction Industry **37**

3.1.2 Causes of Delay in Large Construction Industries **39**

3.1.3 Causes of Delay in Large Building Construction Projects **40**

3.1.4 Construction Delay: A Quantitative Analysis **44**

3.1.5 A comparative Study of Causes of Time Overruns **46**

3.1.6 Causes of Construction Delay: Traditional Contract **49**

3.2 Success Factors **50**

3.2.1 Determinants of Construction Project Success **51**

3.2.2 Critical Success Factors for Construction Projects **54**

3.2.3 Checklist of Critical Success Factors for Building Projects **56**

3.2.4 Critical Success Factors for Different Project Objectives **58**

3.2.5 Critical Success Factors in the Construction Process **59**

3.2.6 Critical Success Factors over stages of the Project Life Cycle **63**

3.3 Conclusion **64**

CHAPTER 4 RESEARCH METHODOLOGY **67**

4.1 Research Strategy **67**

4.2 The Survey Strategy **71**

4.3 Consensus forming techniques **74**

4.3.1 Interacting group process **74**

4.3.2 The nominal group process **75**

4.3.3 The Delphi process **76**

4.3.4 Comparison of the Different Processes **82**

4.4 The Delphi technique – Ranking the critical success factors **83**

4.5 The Research Procedure **86**

4.5.1 Stage (1): Review literature **87**

4.5.2 Stage (2): Data collection, survey of the local building construction project and analysis **87**

4.5.3 Stage (3): Ranking and validating **89**

CHAPTER 5 DATA COLLECTION, ANALYSIS TECHNIQUES AND STATISTICS: STAGE (2) DELAY FACTOR **92**

5.1 Research Question One **93**

5.2 Sampling and Target Population **96**

5.3 Survey Procedure **97**

5.4 Statistical Method **98**

5.4.1 Relative importance Index **98**

5.4.2 Spearman Rank correlation **99**

5.5 Analysis Procedure **101**

5.6 Research Findings and Results **101**

5.7 Analysis of Data **102**

5.7.1 Causes of Delay **103**

5.7.2 Discussion of Results **105**

5.8 Conclusion **109**

5.8.1 Lack of Communication between Parties **111**

5.8.2 Slow Decision Making **112**

5.8.3 Change Orders **112**

5.8.4 Contractor's Inadequate Planning **113**

5.8.5 Finance and Payment of Completed Work **113**

5.8.6 Subcontractor **114**

5.8.7 Inadequate Contractor Experience **114**

CHAPTER 6 DATA COLLECTION, ANALYSIS TECHNIQUES STAGE (3) CORRELATION OF DELAY FACTORS AND SUCCESS FACTOR **115**

6.1 Survey Structure **116**

6.2 Statistical Methods **118**

6.2.1 Pearson Correlation Coefficient **119**

6.2.2 Independent t test **119**

6.2.3 One-Way ANOVA **120**

6.2.4 Two-Way ANOVA **121**

6.3 Analysis Procedures **123**

6.4 Results and Analysis **124**

6.4.1 Participant characteristic **124**

6.4.2 Project information **124**

6.4.3 Owners' characteristic **125**

6.4.4 Contractors' Characteristics **125**

6.4.5 Engineers' Characteristics **126**

6.5 Research question two **126**

6.5.1 Research question 2(I) **127**

6.5.1.1 Owners **127**

6.5.1.2 Contractors **128**

6.5.1.3 Engineers **130**

6.5.1.4 Conclusion **130**

6.5.2 Research Question 2(II) **131**

6.5.2.1 Owners and contractors **131**

6.5.2.2 Owners and engineers **134**

6.5.2.3 Contractors and engineers **137**

6.5.2.4 Conclusion **139**

6.5.3 Research Question 2(III): Individual **141**

6.5.3.1 Owners **142**

6.5.3.2 Contractors **146**

6.5.3.3 Engineers **149**

6.5.3.4 Conclusion **153**

6.5.4 Research Question 2(III): Combined Groups **156**

6.5.4.1 Owners and Contractors 157

6.5.4.2 Contractors and Engineer 165

6.5.4.3 Owners and Engineers 169

6.5.4.4 Owners, Contractors and Engineers 176

6.5.4.5 Conclusion 183

6.5.5 Overall Ranking 184

CHAPTER 7 THE DELPHI METHOD STAGE 3: RANKING THE CRITICAL SUCCESS FACTORS 188

7.1 The Delphi Methodology : Ranking the critical success factors for Brunei construction projects 189

7.2 Tabulation of the First Round Responses 192

7.3 Tabulation and Ranking of Responses from Round Two 193

7.4 Conclusion 194

CHAPTER 8 RESEARCH CONCLUSION AND RECOMMENDATION 198

8.1 Summary of Data collection 198

8.1.1 Critical delay factors in Brunei building construction 198

8.1.2 Relationship between critical success and delay factors (Pearson correlation) 199

8.1.3 Perception of influence of success factors on each delay factor (t-tests of owners, contractors and engineers' responses) **200**

8.1.4 Ranking of critical success factors influence on critical delay factors (One and Two-way ANOVA) **201**

8.1.5 Overall importance of success factors (Importance index) **203**

8.1.6 Delphi technique (Ranking from expert panel) **204**

8.2 Study Conclusion **205**

8.3 Limitation to Research **208**

8.4 Contribution of the Research **209**

8.5 Recommendation for Future Research **210**

REFERENCES **212**

APPENDICES **231**

Appendix A – Gross Domestic Product By Economic Activity **231**

Appendix A1 – Gross Domestic Product Average Annual Growth Rates By Kind of Economic Activity during RKN6, RKN7 and RKN8 **231**

Appendix A2 – Gross Domestic Product by Kind of Economic Activity at Current and Constant Prices, 2000 – 2005 Brunei **232**

Appendix A3 – Percent Distribution of Gross Domestic Product by Kind of Economic Activity at Current and Constant Prices, 2000 – 2005 Brunei Darussalam **233**

Appendix B – t Test success factors and delay factors **234**

Appendix B1 – t Test Owners and Contractors - Success Factors **234**

Appendix B2 – t Test Owners and Contractors – Delay Factors **234**

Appendix B3 – t Test Owners and Engineers – Success Factors **235**

Appendix B4 – t Test Owners and Engineers – Delay Factors **235**

Appendix B5 – t Test Contractor and Engineer - Success Factors **235**

Appendix B6 – t Test Contractors and Engineers – Delay Factors **236**

Appendix C – t Test critical success factors on critical delay factors **237**

Appendix C1 – Owners and Contractors t test – CSFs on CDFs **237**

Appendix C2 – Contractor and Engineers –t Test CSFs on CDFs **240**

Appendix C3 – Owner and Engineer –t Test CSFs on CDFs **240**

Appendix D – One-Way ANOVA Result **248**

Appendix D1 – One-Way ANOVA Results for Owners **248**

Appendix D2 – One-Way ANOVA Summary Results for Owners **249**

Appendix D3 – One-Way ANOVA Results for Owners (Post – Hoc) **249**

Appendix D4 – One-Way ANOVA Results for Contractors **250**

Appendix D5 – One-Way ANOVA Summary Results for Contractors **251**

Appendix D6 – One-Way ANOVA Results for Contractors (Post – Hoc) **251**

Appendix D7 – One-Way ANOVA Results for Engineers **252**

Appendix D8 – One-Way ANOVA Summary Results for Engineers **253**

Appendix D9 – One-Way ANOVA Results for Engineers (Post – Hoc) **258**

Appendix E – Two-Way ANOVA **256**

Appendix E1 – Two-way ANOVA-Owner and Contractor **256**

Appendix E2 – Owners and Contractors – Main effects – Calculation **258**

Appendix E3 – Owners and Contractors – Post Hoc **260**

Appendix E4 – Contractor and Engineer **261**

Appendix E5 – Contractors and Engineers – Main effects – Calculation **263**

Appendix E6 – Contractors and Engineers – Post Hoc **265**

Appendix E7 – Owner and Engineer **266**

Appendix E8 – Owners and Engineers – Main effects – Calculation **269**

Appendix E9 – Owner and Engineers – Post Hoc **271**

Appendix E10 – Owner, Contractor and Engineer **272**

Appendix E11 – Owners , Contractors and Engineers – Main effects – Calculation **275**

Appendix E12 – Owners, Contractors and Engineers – Post Hoc **276**

Appendix F Relative Importance of the Success Factors **278**

Appendix F1 – One-Way ANOVA Results for Owners **278**

Appendix F2 – One-Way ANOVA Results for Contractor **278**

Appendix F3 – One-Way ANOVA Results for Engineer **278**

Appendix F4 – Two-Way ANOVA Results for Owner and Contractor **279**

Appendix F5 – Two-Way ANOVA Results for Contractor and Engineer **279**

Appendix F6 – Two-Way ANOVA Results for Owner and Engineer **279**

Appendix F7 – Two-Way ANOVA Results for Owner, Contractor and Engineer **279**

Appendix G Survey Questionnaire – Delay factors **280**

Appendix H Survey questionnaire – Examine correlation of critical success factors and delay factors **285**

Appendix I Delphi questionnaire **301**

LIST OF TABLES

Table 2.1	Status of RKN8 by Category of Project	**23**
Table 2.2	Financial Status of RKN8 – Expenditure (BND million)	**24**
Table 2.3	Construction Project Parties' Roles	**28**
Table 3.1	Delay Factors in Order of Importance	**38**
Table 3.2	List of Causes of Delay Categorised into Nine Groups	**41**
Table 3.3	Most Important Delay Factors According to Contractors	**43**
Table 3.4	Most Important Delay Factors According to Architectural Engineers	**43**
Table 3.5	Most Important Delay Factors According to Owners	**44**
Table 3.6	Summary of the Investigated Project Frequency of Delay	**45**
Table 3.7	Respondents' Rankings of Significant Delay Factors (A Comparative Study of Causes of Overruns)	**48**
Table 3.8	Relative Index and Ranking of Delay Factor (Causes of Construction Delay: Traditional Contract)	**49**
Table 3.9	Factors Affecting the Success of Construction Project	**54**
Table 3.10	Critical Success Factors for Different Project Objectives	**59**
Table 4.1	Relevant Situations for Different Research Strategies	**71**

Table 5.1	Demographic Characteristic of the Respondent	**102**
Table 5.2	Ranking Causes of Delay (Based on overall)	**103**
Table 5.3	Causes of Delays (Owners, Contractors and Engineers)	**104**
Table 5.4	Spearman Correlation (Owner, Contractor and Engineer)	**105**
Table 5.5	Summary Results of Critical Delay Factors	**110**
Table 6.1	Critical Success Factors and Critical Delay Factors	**116**
Table 6.2	One-Way ANOVA Equations	**121**
Table 6.3	Two-Way ANOVA General Equations	**122**
Table 6.4	Research Question 2 (I, II, & III)	**126**
Table 6.5	Correlation Coefficient – Success and Delay Factors by Owners	**128**
Table 6.6	Correlation Coefficient – Success and Delay Factors by Contractors	**129**
Table 6.7	Correlation Coefficient – Success and Delay Factors by Engineers	**130**
Table 6.8	t-tests – Critical Success Factors (Owners and Contractors)	**132**
Table 6.9	t-tests – Critical Delay Factors (Owners and Contractors)	**132**
Table 6.10	t-tests – Influence of Success Factors on Delay Factors (Owners and Contractors)	**133**
Table 6.11	t-tests – Critical Success Factors (Owners and Engineers)	**134**

Table 6.12	t-tests – Critical Delay Factors (Owners and Engineers)	**135**
Table 6.13	t-tests – Influence of Success Factors on Delay Factors (Owners and Engineers)	**136**
Table 6.14	t-tests – Critical Success Factors (Contractors and Engineers)	**137**
Table 6.15	t-tests – Critical Delay Factors (Contractors and Engineers)	**138**
Table 6.16	t-tests – Influence of Success Factors on Delay Factors (Contractors and Engineers)	**139**
Table 6.17	One-Way ANOVA Results for Owners	**143**
Table 6.18	One-Way ANOVA Summary Results for Owners	**144**
Table 6.19	One-Way ANOVA Results for Owners (Post-Hoc)	**145**
Table 6.20	One-Way ANOVA Results for Contractors	**146**
Table 6.21	One-Way ANOVA Summary Results for Contractors	**147**
Table 6.22	One-Way ANOVA Results for Contractors (Post-Hoc)	**148**
Table 6.23	One-Way ANOVA Results for Engineers	**149**
Table 6.24	One-Way ANOVA Summary Results for Engineers	**150**
Table 6.25	One-Way ANOVA Results for Engineers (Post-Hoc)	**151**
Table 6.26	Two-Way ANOVA Analysis Results Summary for Owners and Contractors	**158**
Table 6.27	Two-Way ANOVA Results for Owners and Contractors	**159**

Table 6.28	Group Main Effect (Owners and Contractors)	**160**
Table 6.28a	Group Main Effect (Owners and Contractors) - D2	**160**
Table 6.28b	Group Main Effect (Owners and Contractors) - D3	**161**
Table 6.28c	Group Main Effect (Owners and Contractors) – D5	**161**
Table 6.28d	Group Main Effect (Owners and Contractors) – D6	**162**
Table 6.28e	Group Main Effect (Owners and Contractors) – D7	**162**
Table 6.29	Group Interaction (Owners and Contractors) – D2	**164**
Table 6.29a	Group Interaction (Owners and Contractors) – D4	**164**
Table 6.29b	Group Interaction (Owners and Contractors) – D7	**165**
Table 6.30	Two-Way ANOVA Analysis Results for Contractors and Engineers	**165**
Table 6.31	Two-Way ANOVA Results for Contractors and Engineers	**166**
Table 6.32	Group main Effect (Contractors and Engineers)	**167**
Table 6.32a	Group main Effect (Contractors and Engineers) – D1	**167**
Table 6.32b	Group main Effect (Contractors and Engineers) – D3	**168**
Table 6.33	Group Interaction D4 & D7 (Contractors and Engineers)	**169**
Table 6.33a	Group Interaction in D7 (Inadequate Contractor Experience)	**170**

Table 6.34	Two-Way ANOVA Analysis Results Summary for Owners and Engineers	**170**
Table 6.35	Two-Way ANOVA Results for Owners and Engineers	**171**
Table 6.36	Group Main Effect (Owners and Engineers)	**172**
Table 6.36a	Group Main Effect (Owners and Engineers) – D1	**172**
Table 6.36b	Group Main Effect (Owners and Engineers) - D2	**173**
Table 6.36c	Group Main Effect (Owners and Engineers) – D3	**173**
Table 6.36d	Group Main Effect (Owners and Engineers) – D4	**174**
Table 6.36e	Group Main Effect (Owners and Engineers) – D6	**174**
Table 6.36f	Group Main Effect (Owners and Engineers) – D7	**175**
Table 6.37	Group Interaction D4 (Owners and Engineers)	**176**
Table 6.38	Two-Way ANOVA Analysis Results Summary for Owners, Contractors and Engineers	**176**
Table 6.39	Two-Way ANOVA Results for Owners, Contractors and Engineers	**177**
Table 6.40	Group Main Effect (Owners, Contractors & Engineers)	**178**
Table 6.40a	Group Main Effect on D1 (Lack of communication)	**179**
Table 6.40b	Group Main Effect on D2 (Slow decision making)	**179**
Table 6.40c	Group Main Effect on D3 (Change orders)	**180**

Table 6.40d	Group Main Effect on D6 (Subcontractors)	**170**
Table 6.40e	Group Main Effect on D7 (Inadequate contractor experience)	**181**
Table 6.41	Interaction (Owners, Contractors and Engineers) -D4 (Inadequate contractor planning)	**182**
Table 6.41a	Interaction (Owners, Contractors and Engineers) -D7 (Inadequate contractor experience)	**182**
Table 6.42	One-Way ANOVA Summary Result for Owners Ranking	**185**
Table 6.43	Success Factor One in Owner Case	**186**
Table 6.44	Group Overall Perceived Success Factors' Importance	**186**
Table 7.1	Results of Study of Critical Success Factors for Critical Delay Factors	**188**
Table 7.2	Delphi First Round	**193**
Table 7.3	Delphi Final Ranking	**194**

LIST OF FIGURES

Figure 2.1	Location of Brunei Map of South East Asia	**16**
Figure 2.2	Map of Brunei Darussalam by District	**17**
Figure 2.3	Gross Domestic Product (GDP) Growth Rate 2001 – 2005	**20**
Figure 2.4	Ministry of Development Organization	**22**
Figure 2.5	Total Allocation of RKN8 by Sectors	**23**
Figure 2.6	Actual Development Expenditure of RKN8 by Sectors	**24**
Figure 3.1	Problems Causing Delays in Construction Projects	**39**
Figure 4.1	The Empirical Scientific Research Cycle	**68**
Figure 4.2	Empirical Research Strategies	**69**
Figure 4.3	Research Procedure	**86**

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE RESEARCH

An examination of the relevant recent literature indicates that construction projects are frequently completed with large cost overruns, extended schedules and quality concerns. Delay is defined as the time overruns either beyond the completion date specified in the contract, or beyond the date that the parties agreed upon for delivery of the project. A delay in a construction project may cause losses, or negatively affect some or all of the project parties. The effects of delay may include time overrun, cost overrun, disputes, arbitration, litigation, and total abandonment (Aibinu and Jagboro , 2002; Manavazhi and Adhikari, 2002; Chan and Kumaraswamy, 2002; Murali and Yau, 2006). Some studies directly examine delays and attempt to identify their causes as well as ways to avoid them (Baldwin, 1971; Assaf et al, 1995; Al-Ghaffy, 1995; Ongulana and Pramkuntong; Chan and Kumaraswamy, 1997; Odeyinka and Yusuf; Mansfield; Kaming et al, 1997; Al-Momani, 2000; Frimpong et al; Assaf and Al-hejji; Odeh Bettaineh, 2002).

During the last four decades a number of studies have investigated factors which aid successful completion of projects, particularly those which affect project success more than others (Martin, 1976; Locke, 1984); Cleland and King, 1983; Sayles and Chandler, 1971; Baker et.al, 1983 Pinto and Slevin, 1989; and Morris and Hough, 1987). “Critical success factors thus are, for any business, the limited number of areas in which results, if they are satisfactory, will ensure competitive performance” Rockart, (1982, p4).

The concept of success in a construction project can, according to some researchers be evaluated only when the evaluation dimensions are adequately defined (Baker et.al, 1983; Slevin and Pinto, 1986; Morris and Hough, 1987, and Turner 1993). Generally, in any project the evaluation dimensions correspond to the traditional constraints of time, cost, and quality parameters. Ashley et al (1987, p71) defined project success as "results better than expected or normally observed in terms of cost, schedule, quality, safety, and participant satisfaction". The first study to identify lists of critical success factors was undertaken by David Ashley (1987), who identified which factors were most influential in successfully completing construction projects.

Mengesha (2004) indicates that research into critical success factors has been undertaken since 1967, and demonstrates the development of information on critical success factors based on empirical and theoretical studies (Ruben and Seeling, 1967 Empirical; Sayles & Chandler, 1971; Martin, 1976; Baker et al, 1983 Empirical; Cleland and King, 1983; Pinto and Selvin, 1987; Tukel & Rom, 1995 Empirical; Walid and Oya, 1996 Empirical and Pinto and Kharbanda, 1995).

This thesis builds on these past studies by investigating the success and delay factors they identify. This work examines success and delay factors in an integrated fashion to determine which critical success factors are most influential in avoiding particular critical delay factors. This will provide organizations involved in construction projects with the foundation on which such strategies - on how to avoid delays - can be developed in the future. This research focuses on building construction projects in Brunei, which were assessed for delay factors, and examines the correlation between the critical success and delay factors identified, allowing the ranking of success factors for these construction projects.

Once the critical success factors are identified, the opportunities for improving project performance within the public sector delivery of Brunei building construction projects are discussed. The research will determine the relevance and applicability of these factors for the Brunei Darussalam Construction Industry, with its inherently unique Asian culture, political system and environmental issues. In the Brunei construction industry, project performance is traditionally evaluated using schedule, cost and quality performance, also known as the “iron triangle” (Atkinson, 1999).

In developed and developing countries, the construction industry plays a major role in the economy by contributing significantly to the gross domestic product, employing a sizable portion of the working population, accounting for about half of the capital formation, and interacting strongly with other sectors of the economy (Hillebrandt, 1985). With the economic development currently taking place in Brunei, it can be demonstrated that there is very low contribution from the construction industry to the economic growth of Brunei Darussalam. In Brunei building construction projects, it can further be demonstrated that there is very little achievement towards the implementation of the National Development program as highlighted in the Brunei Darussalam long term development plan (2007 -2017), where only 35% percent of the total allocated projects in the RKN8 (Eight National Development Plan - 2001 to 2006) were implemented, with 32% on-going and 33% in preliminary stages.

1.2 RESEARCH OBJECTIVES

The aim of the research is to improve project management performance in the construction industry in Brunei. The objectives of the research are:

- To identify the delay factors that currently exist in the construction industry in Brunei Darussalam by exposing the most common and fundamental problems affecting project delivery performance.
- To identify the critical success factors which are most influential in avoiding or preventing critical delay factors. This will be undertaken through an examination of the correlation between critical success factors and delay factors in construction projects.
- To identify, using a consensus expert panel, the most important critical success factors for the Brunei building construction industry.

1.3 RESEARCH QUESTION

Project success in the Brunei construction industry is currently very low. The Brunei Darussalam Long Term Development Plan (2007–2012) indicates the Gross Domestic Product (GDP) average annual growth rate of Brunei Darussalam during RKN8 (2001-2006) was short of the targeted rate of 5-6 percent. This was reportedly due to the slow progress in implementation of RKN8 programs and projects and the decline in the production of oil and gas. This research investigates ten building construction project failures in Brunei with the intention of understanding the reasons for these failures. By understanding the failure and determining the correlated success factors, improvements to the industry can be made by focusing on those issues that have the greatest impact.

The researcher's experience with problems in construction projects in Brunei and the preliminary study of the selected projects in Brunei building projects that encountered delay, reflect those identified in the literature. However this will be confirmed in this study. Common contractor-related problems are that the project is not completed or delivered within the specified period; reduced quality; use of unspecified materials; excessive budgets; unqualified employees; project failures and withdrawals; inadequate construction methods; maintenance problems; and safety problems such as project site accidents.

The research also observed similar deficiencies for owners. Owner-related factors common to the construction industry are late payment for completed work; owner financial issues; owners' interference; frequent change orders; and slow decision making. Further, there are problems with owners or service organizations exercising bureaucratic authority over the contractors, and making unrealistic requests or orders after the contract had been signed. Some of these demands included requesting specific subcontractors or materials, or cutting the costs of any additional work. Additionally, some of the owners or owners' representatives were less than generous with contractors, limiting the amount of profit they could make on their projects.

Engineering-related problems include discrepancies and mistakes in design documents; delays in producing design documents; inadequate drawing details; unclear drawings; complexity of project design; and lack of communication and coordination between project teams. Furthermore, engineers sometimes fail to perform the necessary prequalification procedures, and fail to rely on valid information from the contractor; submissions by contractors were blindly trusted, and no effort was made to verify that the previously-executed projects mentioned in the submissions were genuine and carefully executed by the contractor.

These problems all have had a negative effect on the parties involved by potentially generating significant losses for all. They threaten the general safety of construction projects, and eventually affect the economy as a whole. In light of these issues, this research investigates these problems in order to highlight the importance of the success factors that could prevent or eliminate the delay factors. The research proposes that simply applying critical success factors or taking the necessary precautions might not be enough to enable project partners avoid critical delay factors during construction. Further investigation to examine the correlation between the critical success and the critical delay factors will allow contract parties and investors to determine which factors deserve the most attention.

To this end, the research questions posed for these research problems are:

1. What are the real causes of project delays in the Brunei building construction industry?

2. How are these delay factors correlated to critical success factors within the construction industry?

1.4 JUSTIFICATION OF THE RESEARCH

For every finished construction project in Brunei, a number of deficiencies or delays occur, and continue to occur. Occasionally, new problems develop and despite efforts to implement success factors, these problems have persisted. These problems were observed in the status of RKN7 (Seventh National Development Plan) and RKN8 (Eighth National Development Plan). Review of the RKN7 showed that a total of 405 projects were not implemented and were subsequently dragged to RKN8. In RKN8, only 283 projects out of a total of 808 (35% of the total), were implemented (Brunei Darussalam – Long Term Development Plan).

While a body of research exists that identifies major causes of project delay and further literature identifies a range of success factors, no research was found to exist which illustrated the relationship between success factors and delay factors in building construction projects, and how knowledge of this interaction may allow the delivery of more successful projects. This study is also the first to measure and rank these relationships in order to help project parties minimize construction project problems. This gap in the research has motivated the current study.

Brunei lacks empirical research in this area of study. This research is the first of its kind to investigate the key success factors for project success in Brunei building projects. This research forms a foundation on which further local research can be conducted. Internationally, the outcome of this research may serve as evidentiary data from which other comparative studies could develop in terms of different cultural, social, political and environmental issues.

1.5 RESEARCH METHODOLOGY

The research methodology adopted for this research comprises three stages as follows:

- Stage 1 - literature research to determine the research focus

- Stage 2 – This stage consists of two activities as follows:
  - Activity 1 - specific survey of stakeholders (owners, contractors and engineers) to identify the delay factors of the projects.

  - Activity 2 – general survey of stakeholders (owners, contractors and engineers) to examine the correlation of the critical success factors and delay factors.

- Stage 3 – The Delphi method, as a popular qualitative research approach, is used to obtain a consensus of opinion among a selected group of Brunei experts, to rank the factors selected for possible development to improve project performance in Brunei construction projects.

1.6 OUTLINE OF THE RESEARCH

The thesis format follows the logical steps of establishing the research questions, developing the methodology, gathering and analyzing data and drawing conclusions. The thesis is organized into eight chapters as follows:

Chapter 1 discusses the background of the research by highlighting the research problems, research purpose, research objectives, and justification for the research, proposed methodology and thesis organization.

Chapter 2 gives a background on the construction industry in general. It reviews the construction industry in Brunei, and identifies the characteristics of the construction sector. Problems and constraints in the development of the construction industry in Brunei and other developing countries are discussed. This chapter also outlines the role of the construction industry in the economies of Brunei and other developing countries.

Chapter 3 presents a literature review on the delay factors and critical success factors. It examines literature and studies about delay factors in the construction industry, large building construction projects, fast growing economies and comparative studies of the causes of delays. The literature and studies on success factors include critical success factors for construction projects, a checklist of critical success factors for building projects, success factors for different project objectives, success factors for construction processes and critical success factors for stages of project life cycle.

Chapter 4 describes the methodology used in the research. This methodology seeks to identify the causes of delay factors and then ranks the success factors most necessary for improved project performance. This chapter reviews the survey method and the consensus-forming method.

Chapter 5 describes the data collection method, analysis techniques and statistics used to identify causes of delay in the local building construction industry.

Chapter 6 explains the data collection method, and the analysis used to determine the correlation between critical delay factors and critical success factors, including measurement of the strength and direction of the relationship between factors.

Chapter 7 is the literature review on the consensus-forming Delphi method. This includes an investigation of the background and history of the Delphi technique, its strengths and weaknesses, application of Delphi, the process of Delphi and shortcomings of the Delphi technique. This chapter also details the analyses of data collected from the expert panel on the ranking of the most required critical success factors.

Chapter 8 is the concluding chapter and discusses the research conclusions, limitations of the research, contribution to new knowledge, and provides recommendations and implications for further research.

CHAPTER 2

OVERVIEW OF THE CONSTRUCTION INDUSTRY

The construction industry is a sector of the economy which is responsible for the planning, design, construction, maintenance and eventual demolition of buildings and works. It is essentially a service industry, obtaining its inputs and outputs from various sectors of the economy with which it is interrelated and interlinked, often in quite complex ways. The importance of construction derives from its role in the generation of constructed physical facilities, and in employment, which in turn, play a critical and highly visible role in the process of development of the country.

Construction encompasses all civil engineering works and all types of new building projects (including housing), as well as the maintenance and repair of existing facilities. In developing countries, as much as one half of total construction output may be in civil engineering projects – transport facilities, power projects, irrigation, drainage, water supplies, etc. Housing generally makes up less than one third of the total output; the remainder is in other buildings – hospitals, schools, offices, factories, hotels, and agricultural buildings (Wells, 1986).

This chapter reviews the construction industry in Brunei – a developing county. It investigates Brunei's construction industry including the role of construction, the characteristics of the construction industry, and the difficulties and challenges and common problems experienced in construction projects.

2.1 CONSTRUCTION INDUSTRY IN DEVELOPING COUNTRIES

In developing countries, the construction industry is a key barometer of economic performance. The construction industry contributes a significant percentage of the gross domestic product (GDP) of these countries and provides employment to a substantial proportion of the working population.

The construction industry plays a major role in the economy. Possible measures of the role of the industry in the economy include:

- The size of the industry is substantial in terms of percentage contribution of construction to GDP. It provides an appreciable share as its output typically constitutes 7 – 10 % of GDP;
- Percentage proportion of construction to Gross Domestic Fixed Capital Formation. The industry is critical to infrastructure development and provides a sizable contribution to fixed capital formation relative to other industries;
- Its value-adding capacity;
- The share of investment devoted to entirely new construction is likely to be higher in developing countries than in developed; and
- Construction is relatively labour-intensive in that it uses a larger number of workers per unit output than most other industries, and as such is important as an employer. The industry employs 5 – 15 % of the labour force in most developing countries (UNIDO, 1993).

2.2 DIFFICULTIES FACED BY CONSTRUCTION INDUSTRIES IN DEVELOPING COUNTRIES

Construction industries in all countries face many difficulties and challenges (Gale & Fellows, 1990; Ofori, 1990). However, the problems facing the construction industry in developing countries are significantly more fundamental, more serious and more complex. In developing countries, these difficulties and challenges sit alongside the general situation of socio-economic stress, chronic resource shortages and a general inability to deal with key issues (Ofori, 2000). Whilst in all countries, the construction industry faces conditions of uncertainty and risk, the sources of such risk are severe in developing countries and include:

- *Instability*

Construction is one of the first industries to feel the effects of an economic recession (UNIDO 1993). This phenomenon, coupled with financial and other business risks, makes the development of this sector difficult. The construction industry in both developed and developing countries is volatile; however, instability and volatility are more severe in developing countries where resources are more scarce (Wells, 1986). Discontinuities and fluctuations which characterize construction demand are also volatile in developing countries (Moavenzadeh, 1984; UNCHS, 1984a). For this reason, local contractors are not able to maintain and develop permanent supervisory staff and skilled labour, nor can they establish an appropriate supply of basic equipment. Although clients (usually the government) may require the use of local contractors to do the work, there may be very few qualified local contractors available (Ruvkun, 1981).

- *Scarce resources*

Many developing countries are richly endowed with natural resources, but most are also characterized by shortage of resources such as money, trained people, technical ‘know how’, and appropriate technology.

- *Relatively unskilled labour forces*

Construction activity in developing countries draws mostly on unskilled labour. A reliable supply of labour will be affected largely by the seasonal demand for agricultural labour (Coukis & Grimes, 1980). Some developing countries promote labour-intensive construction to provide social and economic advantages for the population, even though this procedure might hinder the quality and completion of the construction projects (Coukis & Grimes, 1980). Although labour is abundant in developing countries there tends to be a shortage of skilled labour (Moavenzadeh, 1984).

- *Low levels of productivity, overruns and excessive wastages*

Research into construction projects in some developing countries indicates that by the time a project is complete, the actual cost exceeds the original contract price by 30% while change orders result in an 8.3% cost overrun (Al-

Momani, 1996). Both housing and public buildings experience delays in completion and face constant modifications as work progresses. This has proven to be a serious and very expensive problem in Jordan's construction industry, for example (Al-Momani, 1995). The successful execution of construction projects, keeping them within estimated cost and the prearranged schedules, primarily depends on the existence of an efficient construction sector capable of sustained growth and development in order to cope with the requirements of social and economic development and to utilize the latest technology in planning and execution. Adequate planning at the early stages of a project is critical for minimizing delays and cost overruns (Chalabi & Camp, 1984).

- *Poor infrastructure*

In general, poor infrastructure reduces productivity. Even the existence of an established bureaucracy does not necessarily mean the country has adequate and efficient infrastructure such as roads, water, utilities, transportation systems etc. According to the World Bank (1997), up to 15% of production is lost between the farm gate and the consumer because of poor roads and storage facilities. This has the effect of reducing incomes to farmers and raising costs for urban consumers, thus mitigating against prospects for industrialization.

- *Fraudulent practices, and the inability to adopt best practice*

The cost of materials, fraudulent practices and kickbacks, and fluctuations of material prices are among the most important factors leading to high construction costs in developing countries. Contractors, therefore, may need to increase their budget to allow for 'hidden taxes/costs' in developing countries. Further, the system of competitive bidding does little to alleviate these constraints. In theory, the system of accepting the least cost bid should encourage efficiency; however, contractors, particularly small ones, have very little room for manoeuvre in pricing a tender. The design is fixed, the cost of the material to be used is fixed and rates for hired equipment are fairly standard. A contractor therefore makes a profit by limiting overhead costs, raising labour productivity, and/or rationalizing site organization.

Small contractors also have the difficulty of obtaining credit, as there is no continuity of work and no assurance of jobs. They cannot afford or obtain credit for the purchase of plant and equipment. As a result they are often trapped in a sequence of inefficient technology, leading to low productivity. In contrast the large contracting firms, which are often foreign owned, are well versed in the procedures governing the industry, and also have little difficulty in providing the necessary bonds and guarantees.

- *Financing characteristics typical in developing countries*

In developing countries, large projects are usually funded through loans from international agencies or developed countries' governments, and investments from private firms based in other countries (Zuvekas, 1979).

The most important sources of multilateral finance for construction projects are the World Bank and the International Monetary Fund (IMF). These institutions lend funds at interest rates below those charged by other private leaders and sometimes at no interest (Zuvekas, 1979). Other international lending agencies include the United Nations, represented by organizations such as the World Health Organization (WHO), International Labour Organization (ILO), United Nations Industrial Development Organization (UNIDO) and United Nations Centre for Human Settlement (UNCHS). These agencies fund health centres, education infrastructure and affordable housing settlements.

- *Government influence*

Many of the construction projects in developing countries are so large and costly that they can only be accomplished by direct government involvement. The governments of developing countries generally set the rules for the development of contractual relationships, thereby influencing the public construction sector. The private sector also feels this influence through policies and legislation regarding licenses and permits, sanitary and building codes, minimum wage rates, corporate taxes, rules on importation of materials, and terms and availability of financing for construction (World

Bank, 1984). According to the World Bank (1984) while the construction industry in developed countries is affected by political institutions, it is not as strongly affected as in developing countries. Contractors may, therefore, need to exercise caution, accept greater levels of risk, and purchase additional insurance to cover possible losses. Government responsibility to ensure that improvements are made to the construction industry is best done by encouraging local contractors to increase their capabilities, and enlarging the capacity of local material industries.

- *Informal sector activities*

The informal sector is defined as unregulated and unprotected individuals and enterprises engaged in economic activities in construction, including the supply of labour and production of building materials and components for both the formal construction sector and directly in response to client needs.

According to Tassios (1992) the characteristics of the informal sector are low quality of construction output; instability; resistance to progress and change; and a considerable inertia in using modern materials and/or techniques. The problems and difficulties faced by construction industries in developing countries and the measures to manage them have been extensively investigated and many studies and recommendations have been made to address these difficulties (Ofori 2001, 1994; Turin 1973; Wells, 1986; World Bank, 1984; ILO, 1987; UNCHS, 1981, 1984a). The governments of a number of developing countries have implemented some of these recommendations; however, results have been disappointing and the problems continue (Ofori, 1993 & Kimani, 1988).

Ofori (1994) commented on the lack of progress in implementing these recommendations, claiming that this is due to the inappropriateness of some of the recommendations and the initiatives adopted; poor executive capacity of the implementing agencies; lack of resources for implementations of initiatives; and neglect of the construction industry by governments and their lack of commitment to solving its problems. Another important reason for the lack of progress in construction industry development is the absence of measurable targets in programmes for improving the industry's performance.

2.3 BRUNEI CONSTRUCTION INDUSTRY

2.3.1 Introduction to Brunei

Brunei Darussalam is a small country located on the north-western coast of Borneo Island, facing the South China Sea, and with a land area of about 5765 square kilometres as shown in Fig 2.1. In mid 2008, Brunei had an estimated population of around 400,000. Brunei is divided into four districts: Brunei-Muara district; Tutong district; Belait district; and Temburong district. The capital city Bandar Seri Begawan is located in Brunei-Muara District as shown in Fig 2.2.

Fig 2 .1 Location of Brunei - Map of South East Asia (ref Brunei map.google.com)

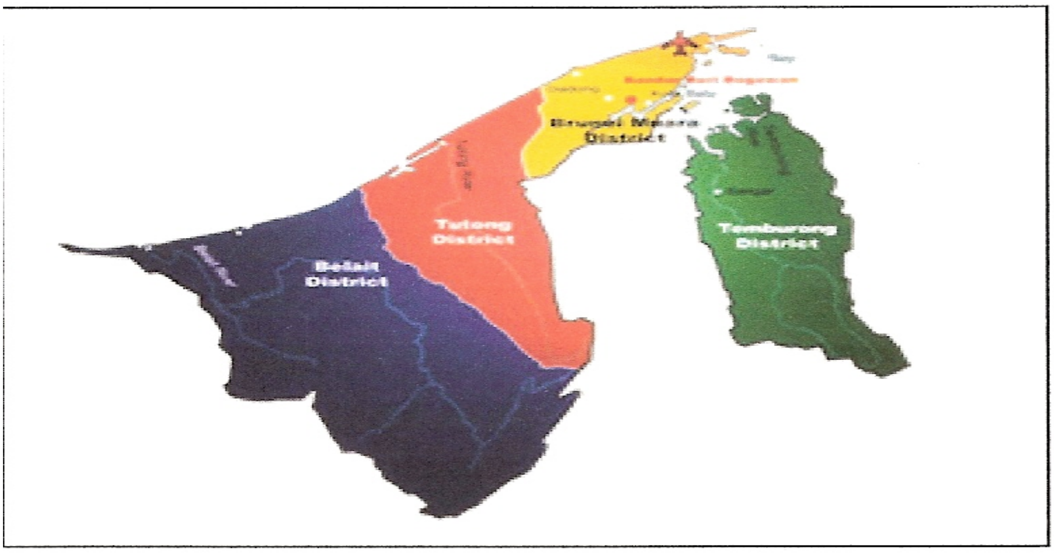


Fig 2.2 Brunei Darussalam by district (ref Brunei Map. google.com)

Brunei adopts a national ideology of Malay Islamic Monarchy. It is an integration of three elements: the Malay language and culture, the teachings of Islamic laws and values, and the monarchy system of administration. His Majesty the Sultan and Yang Di Pertuan Negara Brunei Darussalam formed the Ministry of Development immediately after the proclamation of Brunei Darussalam's independence on 1st January 1984.

Brunei Darussalam today enjoys one of the highest standards of living in Asia. This has been largely the result of political stability, and investment from oil and gas revenues in the country's infrastructure. The economy is still very much dependent on the oil and gas sector. Although oil and gas resources have contributed much to the nation's prosperity, economic growth has, on the whole, not kept pace with population growth.

A new long-term development framework was formulated, for a 30-year period which began in 2007, consisting of the national vision, the outline of strategies and policies for development (OSPD) and the national development plan (RKN). The national vision aims to make Brunei Darussalam, by 2035, a nation which will be widely recognized for the accomplishment of its educated and highly skilled people as measured by the highest national standards; quality of life that is among the top 10 nations in the world; and a dynamic and sustainable economy with income per capita within the top 10 countries in the world.

The launching of RKN 2007–2012 (National Development Plan) marks a strategic shift in the planning and implementation of development projects. RKN 2007–2012 is the first RKN to be formulated based on the objectives of the national vision 2035. In the previous four RKN (1986–2005), development efforts were focused on the following objectives: (i) to improve the quality of life of the people; (ii) to maximize the economic utilisation of natural resources; (iii) to develop non-oil industries; (iv) to accelerate human resources development to meet the country's demand for an increasingly sophisticated economy; (v) to maintain full employment and increase the level of productivity; (vi) to maintain a moderate rate of inflation; (vii) to foster a more disciplined, self reliant and caring society; (viii) to encourage and nurture the development of leaders of industry and commerce; and (ix) to have a clean and healthy environment.

After twenty years of development, significant achievements were made on the objectives of improving the quality of life, maintaining a low inflation rate and a clean and healthy environment. On economic utilization of resources, human resource development (HRD), maintaining full employment and increasing the level of productivity, the achievements were moderate. However, progress on the development of non-oil based industries; the creation of a highly disciplined, self reliant and caring society; and the advancement of leaders of industry and commerce, was relatively low.

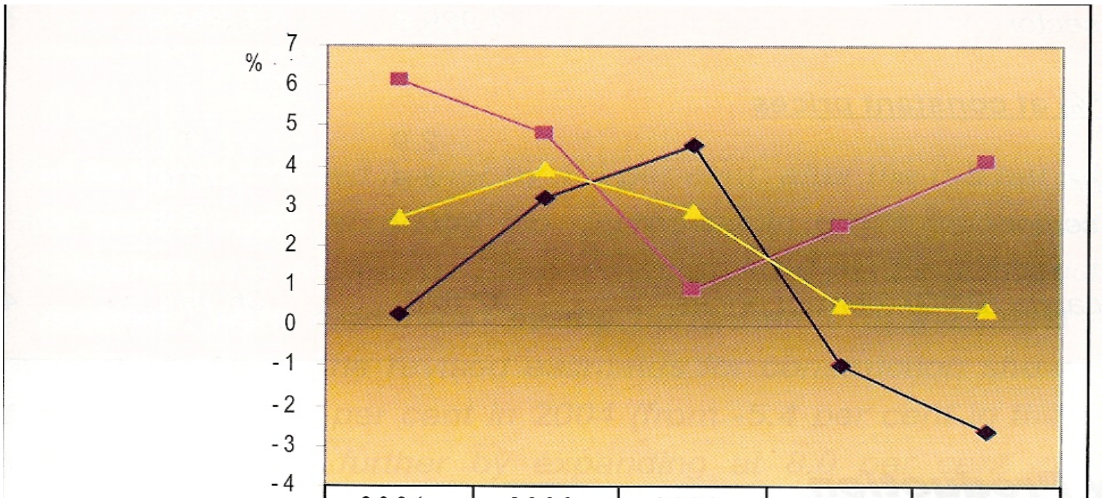
On the economic front, progress has been inconsistent. After some period of growth during the early 1990s, Brunei's economy has shown some signs of weakness in the past few years especially in the aftermath of the Asian financial crisis. In 2005, which marked the end of RKN8 period, Brunei Darussalam's national Gross Domestic Product (GDP) was BND15.9 billion (Aus $13.2 billion). GDP per capita during the period was around BND43,000 (Aus $36,000), which was 35 per cent higher compared to the 2000 GDP per capita of around BND32,000 (Aus $26,000). The oil and gas sector's contribution to GDP was around 54.1 per cent, compared to 57.5 percent at the end of RKN7 in 2000. However, GDP growth in real terms averaged only 2.1 per cent per annum during the RKN8 period. This growth was lower than the targeted annual growth rate of between 5 and 6 per cent. Brunei Darussalam's economy grew slower than the global growth of around 3.8 per cent per year (2000 – 2004) and even slower compared to ASEAN's average of around 5.0 per cent per year in the same period.

Given the heavy reliance of Brunei Darussalam's economy on fiscal stimulus, the delay in the implementation of the development projects has contributed to lower economic growth. This limits the effectiveness of the government's fiscal stimulus strategy. One of the key challenges to accelerate economic growth rates during RKN 2007-2012, therefore, is to enhance the national capacity to carry out development initiatives. To that effect, institutional strengthening is one of the development agenda for the next five years. Bureaucratic processes that determine the efficiency of government's operations will be streamlined in order to improve the quality and efficiency of project implementation.

Under the current trajectory, the rate of disbursement of RKN funds will gradually increase from around half a billion at the beginning of RKN 2007-2012 to BND1.7 billion at the end of RKN 20007-2012. Such a trajectory will translate to an average growth rate of 5 per cent during RKN 2007-2012 period. However, with the expectation of a full implementation of RKN, in combination with improvement in the capacity to spend (achieve at least 80 per cent of the total allocation), the government expects to spend around BND1.7 billion (Aus1.4 billion) yearly which will translate to an average growth rate of 6 per cent. Such a target will only be achieved with the full collaboration and co-operation of all government agencies and the private sector. To achieve this, the development agenda will be shaped by the need to: (i) ensure improvement in implementation; (ii) address impediments to high economic growth and socio economic development; and (iii) meet the vision 2035 goals.

2.3.2 *Brunei Construction Industry*

In developed and developing countries, the construction industry plays a major role in the economy by contributing significantly to the gross domestic product, employing a sizable portion of the working population, accounting for about half of the capital formation, and interacting strongly with other sectors of the economy (Hillebrandt, 1985). This is not happening in Brunei - as shown in Fig 2.3, which demonstrates that there is very low contribution from the construction industry to the economic growth of Brunei Darussalam (Refer to Appendix A1 and A2 showing contribution from all sectors)



	2001	2002	2003	2004	2005
Oil Sector	0.3	3.2	4.5	-1.0	-2.6
Non-oil Sector	6.1	4.8	0.9	2.5	4.1
GDP	2.7	3.9	2.9	0.5	0.4

Fig 2.3 Gross Domestic Product (GDP) growth rate 2001 to 2005. (Brunei Darussalam Long-Term Development Plan)

The National Development Plans ensure that the state funding allocation is not just concentrated on maintaining the peace and prosperity of the country as well as the standard of living of the people, but also on enhancing economic activity, particularly in the private sector, by capitalizing on Brunei's competitive advantages. These include Brunei's political stability and the stability of its currency; its educated, productive population and workforce; the high quality basic amenities and infrastructure; and the government's pro-business and pro-investment outlook. If the allocations of budget are spent appropriately and wisely, then the government can expect to achieve a better growth rate.

The Ministry of Development has been assigned the responsibility of planning and providing physical infrastructure for the nation. These projects are to ensure that there is continuous improvement in the standard of living of the people as well as to strengthen the economic and social development of Brunei Darussalam in a coordinated and structured manner. The Ministry of Development, through its units and departments, strives to improve the standard of living and quality of life by making available to public and potential investors, modern and up-to-date facilities and services. The following chart shows the various departments and their relationships within the Ministry of Development (Fig 2.4).

The Ministry of Development has constructed many projects as part of its National Developments Plan. The Government of Brunei has approved large amounts of money for the implementation of projects and programmes in the National Development Plan – the funds being allocated to seven sectors as follows:

(1) Industry and Trade;
(2) Transportation and Communication;
(3) Social Services;
(4) Public Utilities;
(5) Public Buildings;
(6) Security and
(7) Miscellaneous.

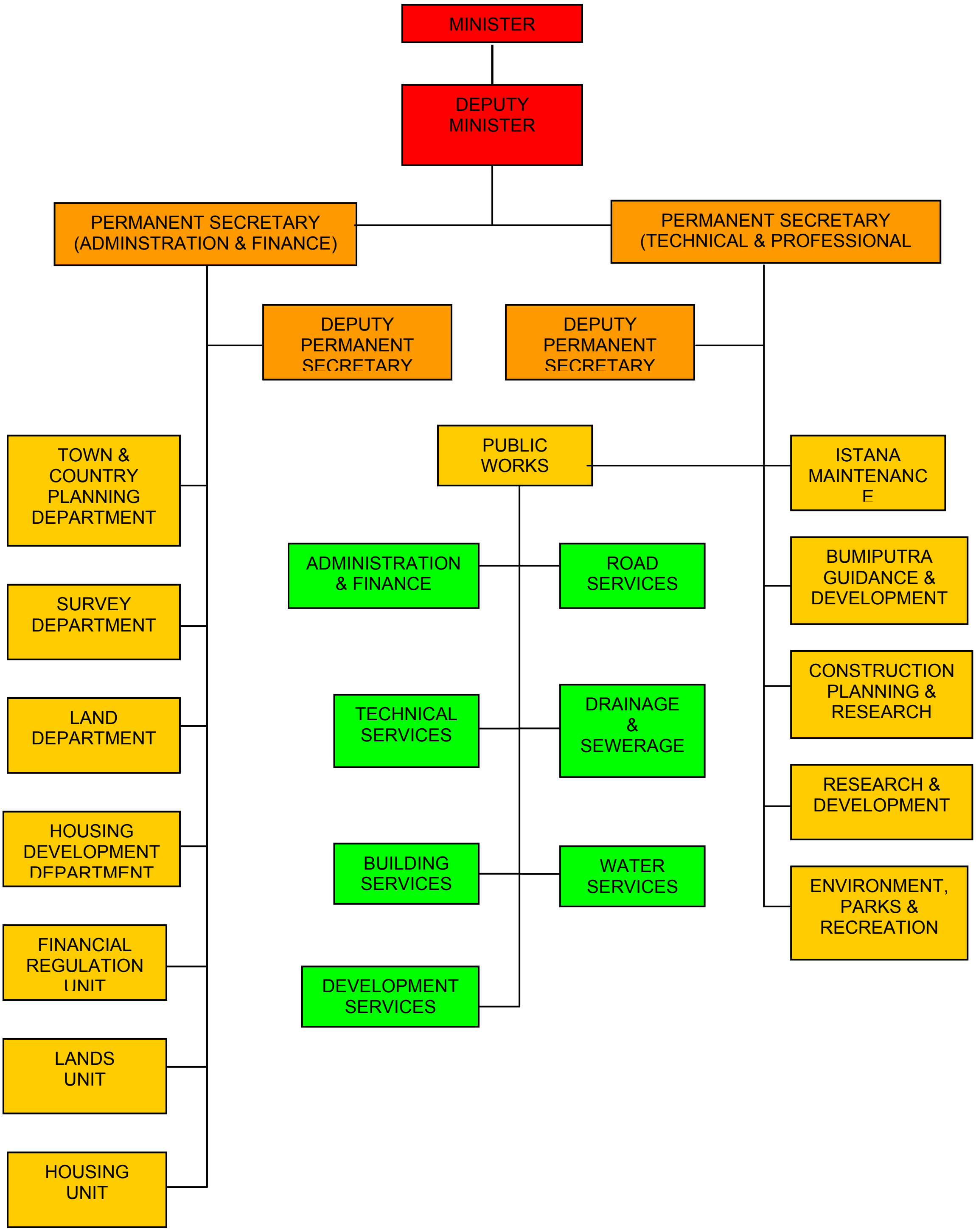


Fig 2.4 Ministry of Development Organization (Ministry of Development-2007)

There were 808 projects being funded during RKN8. The sectoral breakdown is given in Fig (2.5). The social services sector received the biggest share with a total scheme value of almost BND2 billion (Aus1.6 billion).

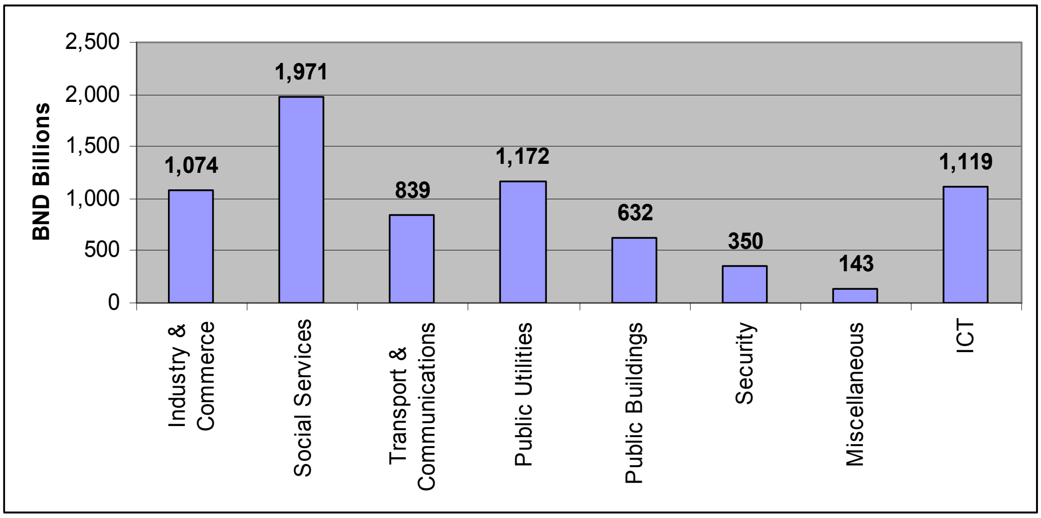


Fig (2.5) Total Allocation of RKN8 by Sectors (Brunei Darussalam Long-Term Development Plan)

Out of 808 projects, only 283 projects (or 35 per cent of the total) were completed, while 253 projects are still on-going, and the remaining 272 projects are at the early stages in their project cycles. These include projects which are in the process of tendering, pre-design, concept formulation and those awaiting appointment of consultants. See table (2.1)

Table2.1 Status of RKN8 by Category of project (Brunei Darussalam Long-Term Development Plan)

Project Status	**2001**	**2002**	**2003 – March 2004**	**April 2004 – March 2005**	**April 2005 – March 2006**
Completed	72	85	172	241	283
On-Going	97	147	200	203	253
Preliminary Stages	328	503	387	320	272
Grand Total	497	735	759	764	808

As of March 2006, the total development expenditure was BND 1,845 million (Aus1.540 million) or 42 per cent of the total allocation (Table2.2). The actual expenditure for sectoral development is shown in Fig (2.6).

Table (2.2) Financial status of RKN8 – Expenditure (BND million)

Financial Year	Allocation	Expenditure	Percentage
2001	550	202	36.7
2002	1,000	435	43.5
Jan 2003 – March 2004	1,000	366	36.6
April 2004 – March 2005	900	355	39.4
April 2005 – March 2006	900	487	54.1
Total (2001 – March 2006)	4,350	1,845	42.4

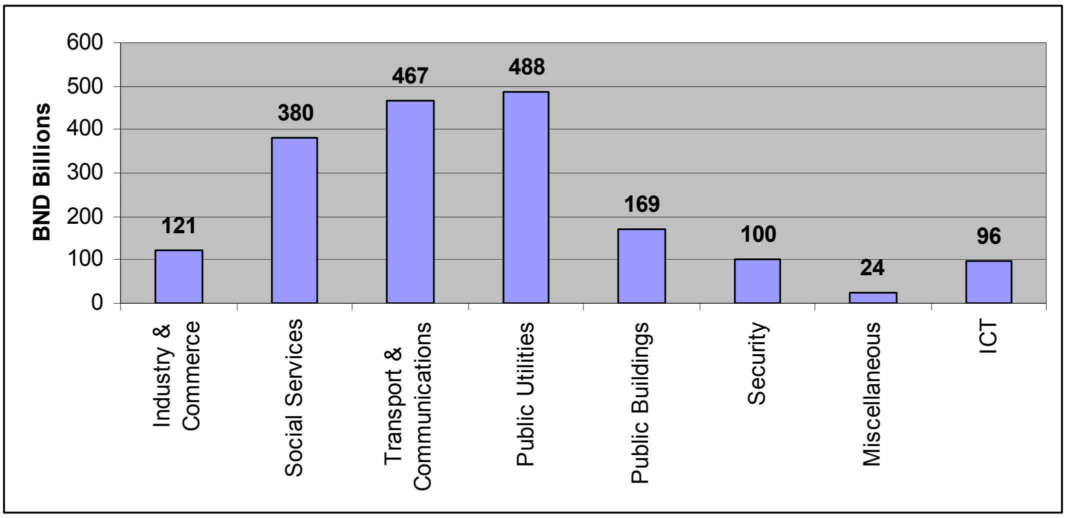


Fig 2.6 Actual Development Expenditure of RKN8 by Sectors (Brunei Darussalam Long-Term Development Plan)

It has been shown (refer to Table 2.1) that there has been very little achievement towards the implementation of the National Development programme. It has become somewhat of a trend that projects allocated for the one National Development Plan drag on to the next National Development Plan. Projects not completed (refer to Table 2.1), which were on-going or at a preliminary stage, will extend to the next RKN9 (2007-2012). It has become a goal of the Ministry to improve and achieve the development plan successfully in order to deliver His Majesty's objective of ensuring that there are continuous improvements in the standard of living of the people, as well as to strengthen the economic and social development of Brunei Darussalam. The Public Works Department, under the Ministry of Development, is the prime agency for the implementation of construction projects. The implementation of construction projects are in accordance with the Brunei Darussalam Construction Regulation.

It has been noted in many Brunei construction projects that poor performance is often interpreted as project failure. Such project failures are commonly due to delay factors where projects are well behind schedule (Economics Development Board Annual Report 2005). One of the critical failures faced by government authorities is the frequent and lengthy delay in such projects. It was found that delayed projects accounted for approximately 70% of projects undertaken by the Public Works Department. In a preliminary study of building construction implemented in the Public Works Department conducted for the purpose of this research, it was found that 68% of the projects completed during the period 1996-2004 had been delayed. Ten projects were randomly selected from the delayed projects and it was found that their average extent of delay was 80%.

The problem of project delay in the construction industry is a global phenomenon and the construction industry in Brunei is no exception. Frequent and lengthy delays of projects have become one of the most critical problems affecting Brunei building construction projects. It has been found (Public Works Department report) that up to 70% of projects are well behind schedule. It has also been identified that 70% of projects for the last National Development Plan (RKN7) had not been implemented (project review RKN7-Economic Planning Unit). The RKN8 National Development Plan is also exhibiting very slow implementation of projects (Brunei Darussalam-Long Term Development Plan 2007-2012).

The main purpose of this study is to identify the delay factors and their effect on project success – identifying and addressing delay factors can help project parties reach their intended goals with greater efficiency. This study will identify the critical success factors in developing countries and determine which were the most influential in preventing project delays in the Brunei construction industry with its unique culture, political system and environmental issues.

2.4 CONSTRUCTION CLASSIFICATION : BRUNEI CONSTRUCTION INDUSTRY

The strategies and operational relationships between construction project parties are directly related to the type of construction project, and there are different ways to classify them. According to Halpin and Woodhead (1998) there are three major construction categories:

- Heavy and highway: construction of highways, bridges, airports, pipelines, dams and tunnels.
- Non residential buildings: either institutional or educational buildings (such as schools or universities, warehouses, and government buildings) or industrial (such as petroleum refineries or nuclear power plants).
- Residential: construction of single-family homes, multiunit town houses, or high-rise buildings.

The types of projects most common in the Brunei construction industry, and which are considered to be the backbone of Brunei's development efforts, include the following:

- Public housing
- Schools or Universities
- Industrial facilities
- Commercial buildings
- Power plants
- Dams
- Irrigation system
- Roads and transportation

- Water purification plants
- Health and sanitation facilities
- Government buildings.

2.5 PROJECT PARTIES: BRUNEI CONSTRUCTION INDUSTRY

Table 2.3 summarises the construction project parties' roles. The primary construction project parties are:

1. Owner: Owners play the most important role in the construction project life cycle by defining project requirements, functions and services. Also, owners are responsible for providing financial support to a project.

2. Contractor: Firms or individuals generally contract with owners in order to execute certain projects according to specific conditions. The contractors are usually private contractors who undertake to construct the project under certain terms and conditions, and to the design and specifications provided by the project teams.

3. Designer (Architect/Engineer): The third party in construction projects is the designer, who interprets the owner's needs and creates a tangible blueprint of a project. For some projects, the designer also assumes the role of supervising activities during the construction phase. The project team usually includes the various departments within the ministry of development as well as a private consultant who is appointed to implement government projects.

4. Government Regulatory Agencies involved in the project: These agencies include, among others, electrical services, public works department (building, water , sewerage, structure, etc), fire brigade, Economic Planning unit, health, Town and Country planning, the Land Department and Survey Department.

Table 2.3 Construction Project Parties Roles

CONTRACT PARTY	ROLES
Owner	➢ Determines whether it is necessary to build the facility ➢ Provides financial support to develop the project ➢ Determines the scope of work ➢ Most important player in the process
Contractor	➢ Creates the facility based on the A/E's drawings and specifications ➢ Manages different resources during the project's development phase
Architect/Engineer (A/E)	➢ Responsible for project design ➢ Fortifies the final project ➢ Determines which materials will be used and how they will fit together ➢ Develops the project's drawing and specifications

2.6 PROJECT DEVELOPMENT: BRUNEI CONSTRUCTION INDUSTRY

Traditionally construction projects develop in a clearly sequential fashion, and the general steps involved are as follows:

1. The need for a facility is defined by the owner.
2. Initial feasibility and cost projections are developed.
3. The decision to either proceed with the conceptual design or improve the idea is made.
4. The conceptual design and scope of work is developed in order to determine a cost estimate.
5. A decision is made to proceed with the development of final design documents.
6. Based on the final design document, the project is advertised and proposals, including costs for construction work, are solicited.
7. Based on the received proposal, a contractor is selected and instructed to proceed with the work.
8. The process of constructing the facility is initiated.
9. Work is completed and the facility is available for acceptance and occupancy/utilisation.

10. A period of testing takes place to ensure the facility is constructed properly and operates as designed.
11. The facility operates and is maintained for the duration of its specified service life.

2.7 COMMON PROBLEMS: BRUNEI CONSTRUCTION INDUSTRY

The delays experienced during the stages of construction in Brunei can be identified in three overlapping areas: problems of shortages or inadequacies in industry infrastructure; problems caused by clients and consultants/engineers; and problems caused by a contractor's incompetence/inadequacies. The researcher reviewed the projects which encountered delays, and based on follow-up discussion with stakeholders (Owners, Engineers, Consultants and Contractors) the following were cited as common problems in the Brunei building construction process:

2.7.1 Owners

The most frequently cited cause of delay for construction projects in Brunei is change orders from the owners. There are two types of delay: compensable and non compensable delay (these delays are explained in chapter 3). For marketing reasons, change orders tend to occur more often in private projects because private owners are in the habit of changing plans to meet customer demand and in line with the changing economic climate. Contractors accused owners of being slow in decision making, and requests from owners are usually made at short notice, thereby impacting on a contractor's plan. Some change orders can be large, requiring extensive redesign. These results, in many instances, in contractors wasting resources while waiting for owners to decide on specialty contractors and designers, decorative materials and suppliers, and provision of adequate information on the changes required.

2.7.2 Engineers/Designers

There is a general consensus that one of the major causes of project delays is due to the designer's incomplete drawings, particularly inconsistent detailing of drawings. Investigations also identified several instances of incorrect dimensioning of walls and openings, differences in dimensions between plans and sections, inadequate detailing of difficult locations and inconsistent detailing. Delays are also linked to the boom in the construction industry, which resulted in many design offices being overloaded and understaffed. Consequently, project designs are often rushed to tender in a short time to meet bid dates, with no proper feasibility studies, and without detailed briefing. This results in many contracts being bid with incomplete information, and thereby requiring extensive changes during construction. The rush to complete designs also creates problems of coordination between the architectural, structural, mechanical, sanitary, electrical and other systems.

Other reasons for design-originated delays include the problems of personnel or project teams. These problems are related to a lack of technical staff in the construction industry and a shortage of design professionals. The site personnel delegated by design practices are often unqualified and may not have been involved in the original design. They are thus not able to effect changes without reference to their design offices. Another problem observed is that generally, design offices give higher priority to new projects, creating a lack of supervision and attention to those projects using already-allocated personnel.

2.7.3 Consultant

The appointment of a consultant as a service to a client is common practice in Brunei due to the shortage of skilled engineers and staff. The consultant management firm designs the buildings, ensures that all works accord with drawings and specifications, supervises and coordinates the various activities of the parties to the project. However, consultants are accused of creating delays due to their lack of experience, incompetence, personal interests and uncompromising attitude.

Many consultant management personnel are unwilling to accept contractors' proposed changes, even if the changes are reasonable, because they believe the contractors lack experience. Contractors usually complain that the consultant management firm maintains an uncompromising attitude and, rather than working in harmony to solve problems, are in the habit of finding faults. Contractors also argue that many consultant management personnel are often incompetent, and in trying to protect themselves, are not able to distinguish what is important from what is not. Rather than plan inspections in accordance with the sequence of work, consultant management staff and inspection teams tend to wait to be approached to approve works. Last minute non-approvals cause delays and waste contractors' resources.

2.7.4 Contractors

The contractor is blamed for the majority of project delays, generally being accused of poor management and technical performance. A contractor's lacks of technically qualified and experienced staff lead to poor site organization and management of material and equipment. Poor management leads to inadequate planning, inadequate site management, and lack of coordination. These result in cost, time and budget deficiencies. Contractors argue that the planning and schedule deficiencies are caused by clients who are in the habit of changing their minds very often, whilst insisting that short term planning is unnecessary.

Financing is cited as a specific problem for contractors when they are not paid regularly. Irregular payment on public projects is a major cause of liquidity problems for contractors. However, unreasonably low bidding and contractor's financial difficulties are problems under the direct control of the contractor.

2.7.5 Construction resources suppliers

Demand exceeded the supply of major construction during the boom period where projects were rushed to meet the bid dates. The boom period also saw shortages of import materials. Local manufacturers could not expand production facilities fast enough to meet demand. Import restrictions on major construction materials are believed to be the major cause of shortages. Whenever import permits are granted to meet local demand, the quality of imported material deteriorates and creates problem with the delivery time of materials. Continued expansion in the construction sector of the economy creates supply problems, which drives up the prices of materials. The materials suppliers generally shop for the lowest-priced sources outside the country, with little regard for quality. Therefore, materials' suppliers can afford to charge high prices for poor services. Contractors also complained about the quality of imported materials.

Materials are not the only resource in short supply in periods of economic boom. Qualified architects, contractors, engineers, and skilled labour in general are in high demand during this period. The staff shortage problem is felt at two levels: at the technical level and at the craft level. The shortage of workers is believed to be due to several factors. Demand increases greatly while supply of labour remains constant. The seasonal nature of employment in construction is another major problem. Many workers do not take on construction work all year round. The few skilled construction workers can easily get higher salaries by moving between jobs.

Many construction companies rely on labour suppliers for their site workers as a means of minimising labour management problems. This in turn creates coordination problems. When work is temporarily reduced on one site, the supplier transfers workers to other sites where they are needed. It is then difficult to get enough workers back on the first site when they are needed. These staffing problems have created serious quality control difficulties for project management. It is generally accepted that the often low-quality standards of buildings are due to the quality and supply of construction staff.

2.7.6 Other sources

Delays associated with government authorities centre around the time taken in granting permits and approvals. The relevant authority in Brunei gives separate permits for substructure and super structure work. In Brunei there are also many authorities involved in approving plans before work commences. The authorities involved are land, housing, electric, water, road, environment and health. Therefore, construction projects can be delayed by permit problems and approval from the authorities. Working in cities like Brunei also means having to contend with problems such as lack of transportation, storage space, accommodation, restricted working time, restricted plant movements, etc. Disputes with neighbours are another source of work stoppages, due to their impact on working space for equipment such as tower cranes, as well as restrictions on working times.

In summary, the common problems facing the Brunei construction industry can be classified into the following categories:

- *Finance-related problems*

The common finance-related problems are high cost financing, difficulty in getting loans, interference from owners in decision-making processes, and shortages in funding.

- *Owner-related problems*

The common owner-related problems are lack of strategic management, changes in requirements, inadequate project feasibility studies, lack of clear bidding processes, excessive change orders, unclear responsibility, lack of capable representatives, owner’s financial difficulties, owner’s poor contract management skills, and slow decision making.

- *Contractor-related problems*

Contractor-related problems include inadequate experience, construction errors, poor site management and supervision, equipment failures or allocation problems, inadequate labour skills, inadequate site manager authority, inadequate planning and scheduling, inaccurate estimation, and poor contract management.

- *Consultant-related problems*

Consultant-related problems are attributable to designers and consultants in their preparation and approval of drawings, design errors, delays in work approval, lack of involvement and lack of responsibility.

- *Project attribute problems*

These problems derive from the characteristics of the project. They include ambiguous project scope, lack of constructability, inaccurate site investigation, pollution during construction, non-value added works, inadequate quality assurance and control, unrealistically imposed contract duration and obsolete technology.

- *Coordination-related problems*

These problems include poor communication, excessive use of subcontractors and nominated suppliers, excessive bureaucracy, fraudulent practices and kickbacks, misalignment of a client's expectation, and jurisdictional disputes.

- *Environmental-related problems*

These refer to external problems caused by natural conditions such as inclement weather, or socioeconomic conditions such as material shortage or late delivery, labour shortage, price fluctuations, inconsistent policies and slow government permits.

CHAPTER 3

LITERATURE REVIEW INTO PROJECT SUCCESS FACTORS AND DELAY FACTORS

Increasing uncertainties in technology, budgets and development processes create a dynamic construction industry. Building projects are now much more complex and difficult and the building project team faces unprecedented changes. The study of project success/failure and critical success factors (CSFs) is a means of understanding and thereby improving the effectiveness of construction projects. However the concept of project success remains ambiguously defined in the mind of construction professionals.

One of the objectives of this research is to understand and explain, through a study of the literature, critical success and delay factors. This chapter defines and describes project delay factors and success factors as identified in the literature. The literature review is divided into two parts. The first part summarises the studies on causes of delays to construction projects; the second part explores critical success factors.

3.1 DELAY FACTORS

In the context of the construction industry, delay can be defined as the extra time required to finish a construction project beyond its original (planned) duration, whether compensated for or not. The desire to finish a project on time, under the planned budget, with the highest quality, and in a safe manner is common goals for all contract parties, including the owner, contractor and consultant. Delays usually result in losses of one form or another for everyone. Research indicates the effect of delays as (1) time overrun (2) cost overrun (3) disputes (4) arbitration (5) litigation, and (6) total abandonment (Murali, 2006: Albinu and Jagboro, 2002; Chan and Kumaraswamy, 2002). To control this problem and minimise construction project delays, construction parties should identify the causes of delays and the project factors that may facilitate their avoidance.

Ahmed *et al (*2003) indicates that delays can be divided into three major types, namely:

1. excusable and non-excusable;
2. compensable and non-compensable; and
3. concurrent.

Non-excusable delays are caused by contractors or subcontractors or material suppliers, through no fault of the owner. The contractor might be entitled to compensation from the delaying subcontractor or supplier, but compensation cannot be sought from the owner. Therefore, non-compensable delays usually result in no additional money and no additional time being granted to the contractor (Alaghbari, 2005).

Excusable delays, also known as “force majeure” delays, are the third general category of delay. These delays are commonly called “acts of God” because they are not the responsibility or fault of any particular party. Most contracts allow for the contractor to obtain an extension of time for excusable delays, but no additional money (Alaghbari, 2005). A concurrent delay happens in a situation where more than one factor delays the project at the same time or in overlapping periods of time (Alaghbari, 2005).

Compensable delays are those that are generally caused by the project’s owner or their agent. The most common form of compensable delay is inadequate drawings and specifications, but compensable delays can also arise from the owner’s failure to respond in a timely fashion to requests for information or shop drawings, owner changes in design or materials, and owner disruption and/or change in the sequence of work. The contractor is entitled to both additional money and additional time resulting from compensable delays (Alaghbari, 2005).

Ahmed *et al*, (2003) claim that responsibility for delay is related to whether the contractor is awarded or is liable for costs and additional time to complete the project. The categories of responsibility are:

- Owner responsible – the contractor will be granted a time extension and additional costs (indirect) where warranted;
- Contractor (or subcontractor) responsible – the contractor will not be granted time nor costs, and may have to pay damages/penalties;
- Neither party (i.e. "act of god") responsible – contractor will receive additional time to complete the project but no costs will be granted and no damages/penalties assessed; and
- Both parties responsible – contractor will receive additional time to complete the project but no costs will be granted and no damages/penalties assessed.

Concurrent delays are more complicated but are also a more typical type of delay. They arise when more than one factor delays the project at the same time or in overlapping periods of time (Alaghbari, 2005).

3.1.1 Causes of Delay in the Construction Industry

Much research has been undertaken on construction delay. Baldwin et al. (1971) examined the subject of delays and noticed that large construction projects experienced considerable setback and loss when they encountered any kind of delay. The study included a survey of 1400 professionals, with a response rate of 61% contractors, 44% architects, and 30% engineers. In spite of the different viewpoints held by each of the groups surveyed, there were definite areas of agreement among them. All three groups felt that weather, labour supply and subcontractors' scheduling were the three major causes of delay. Table 3.1 lists the range of delay factors identified by respondents, in order of importance.

Table 3.1 Delay Factors in Order of the Importance (Baldwin et al, 1971)

Contractors	Architects	Engineers
Weather	Subcontractors	Weather
Labour supply	Labour	Subcontractors
Subcontractors	Weather	Labour
Design changes	Manufactured items	Manufactured items
Shop drawings	Finances	Finances
Foundation conditions	Material shortage	Foundation conditions
Material shortage	Shop drawings	Permit
Manufactured items	Permit	Material shortage
Sample approvals	Foundation conditions	Design changes
Jurisdictional disputes	Design changes	Shop drawings
Equipment failure	Construction mistakes	Jurisdictional disputes
Contracts	Jurisdictional disputes	Equipment failures
Construction mistakes	Sample approvals	Construction mistakes
Inspection	Building Codes	Inspection
Finances	Contracts	Contracts
Permits	Equipment failure	Sample approvals

The results of this survey identify three inter-related categories of construction industry problems in developing economies: (a) problems of shortages or inadequacies in industry infrastructure (mainly supply of resources); (b) problems caused by clients and consultants; and (c) problems caused by contractor incompetence/inadequacies. (Ogunlana and Olomolaiye (1989). Figure 3.1 demonstrates the inter-relationship of these problems for the construction industry.

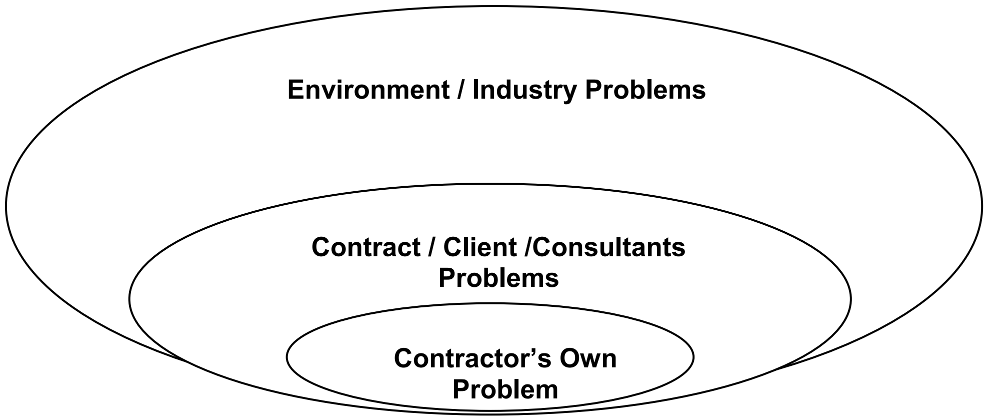


Fig 3.1 Problems causing delays in Construction Projects (Ogunlana and Olomolaiye -1989).

3.1.2 Causes of Delay in Large construction projects

In 2004, Assaf and Al-Hejji conducted a survey on time performance of different types of construction projects to determine the causes of delay and their importance according to each of the project participants – 15 owners, 19 consultants and 23 contractors. The authors identified seventy-three causes of delay (Al-Ghafly, 1995; Chan and Kumaraswamy, 1997; Kaming et al, 1997; Kumaraswamy and Chan, 1998; Noulmanee,1999; Al-Momani, 2000; Ubaid, 1991), and arranged the identified factors into nine groups, as shown in Table 3.2.

Nguyen et al, (2004) conducted a case study from Vietnam on large construction projects in developing countries. The study revealed that there were certain interrelationships among the problems. The top ranked problems in term of occurrence were grouped under five major factors: (1) incompetent designers and contractors, (2) poor estimation and change management, (3) social and technological issues, (4) site related issues, and (5) improper techniques and tools.

In 2008, Shamas-Ur-Rehman Toor and Stephen O. Ogunlana investigated problems causing project delay in Thailand. An inventory of 75 problems categorized under 10 groups was used to examine the most significant problems causing delay in major projects in Thailand. The findings showed that problems related to designers, clients, contractors and finance were rated as most significant, whereas a multicultural and multilingual environment, large number of participants and the involvement of foreign designers were perceived as not very significant problems. Most of the problems listed support the Assaf and Al-Hejji and Nguyen et al (2004) study mentioned above.

3.1.3 Causes of Delay in Large Building Construction Projects

The study undertaken by Assaf et al. (1995) consisted of two phases. The first phase included a literature review and interviews with local contractors, architectural engineers, and owners, where fifty-six causes of delay were identified. These factors were grouped into nine major categories:

- Materials – causes of delay related to shortages, material changes, delivery, damage, and manufacturing of materials;
- Labour – shortages of labour, labour skill, and the nationalities of the labourers;
- Equipment – delay related to failure, shortage, and delivery of the equipment, or the productivity or skill of operators of the equipment;
- Financing – contractor's financing requirements and progress payments paid by owners;
- Environment – climatic conditions, social and cultural impact, geological conditions;
- Changes – delays as a result of omissions, errors, and changes of scope by owners;
- Government relations – delay related to permits, labour visa requirements, and government bureaucratic procedures;
- Contractual relationship – problems involving the contractual relationship among the various parties involved in a project, who have varying and sometimes conflicting interests;

- Scheduling and controlling techniques – poor planning and scheduling practices, lack of management expertise in project control, and poor record keeping and maintenance.

In the second phase of the study, a questionnaire was developed that focused on the fifty-six causes of delay. A survey was conducted to assess the relative importance of each cause of delay on large building projects valued at 10 million Saudi Riyals (Aus $3.2 million) Twenty-four contractors, fifteen architects and engineers, and nine owners completed the survey.

The study found that all three groups generally agreed on the ranking of the delay factors (financing was ranked the highest by all three parties, and the environment was ranked the lowest). Tables 3.3, 3.4, and 3.5 illustrate the most important factors, and their rankings, identified in this study.

Table 3.2 Causes of delay in large construction projects categorised into nine groups (Assaf & Al-Hejji, 2004)

Groups of delay	Causes of delay
Project-related factors	➢ Original contract duration is too short ➢ Legal disputes between various parties ➢ Inadequate definition of substantial completion ➢ Ineffective delay penalties ➢ Type of construction contract (turnkey, construction only, etc) ➢ Type of project bidding and award (negotiation, lowest bidder)
Owner-related factors	➢ Delay in progress payment by owner ➢ Delay in furnishing and delivering the site to the contractor by the owner ➢ Change orders by owner during construction ➢ Delay in revising and approving design documents by owner ➢ Delay in approving shop drawings and sample materials ➢ Poor communication and coordination by owner and other parties ➢ Slowness in the decision making process by owner ➢ Conflicts over joint ownership of the project ➢ Lack of incentives for the contractor for finishing ahead of schedule ➢ Suspension of work by owner
Contractor-related factors	➢ Difficulties in financing the project ➢ Conflicts in sub-contractor's schedule in execution of project ➢ Re-work due to errors during construction

	➢ Conflicts between contractor and other parties (consultant and owner) ➢ Poor site management and supervision ➢ Inadequate construction methods ➢ Delays in sub-contractor's work ➢ Inadequate contractor's work ➢ Frequent change of sub-contractors because of their inefficient work ➢ Poor qualification of contractor's technical staff ➢ Delay in site mobilisation
Consultant-related factors	➢ Delay in performing inspection and testing ➢ Inflexibility ➢ Poor communication/coordination between consultant and other parties ➢ Delay in reviewing and approving design documents ➢ Conflict between consultant and design engineer ➢ Inadequate experience of consultant
Design team-related factors	➢ Mistakes and discrepancies in design documents ➢ Delays in producing design documents ➢ Unclear and inadequate details in drawings ➢ Complexity of project design ➢ Insufficient data collection and survey before design ➢ Misunderstanding of owner's requirements by design engineer ➢ Inadequate design-team experience ➢ Non-use of advanced engineering design software
Materials-related factors	➢ Shortage of construction materials in market ➢ Changes in material types and specifications during construction ➢ Delay in material delivery ➢ Damage of sorted material when they are needed urgently ➢ Delay in manufacturing special building materials ➢ Late procurement of materials ➢ Delay in selection of finishing materials due to availability of many types in market
Plan/equipment-related factors	➢ Equipment breakdown ➢ Shortage of equipment ➢ Inadequate equipment-operator's skill ➢ Low productivity and efficiency of equipment ➢ Lack of high-technology mechanical equipment
Labour-related factors	➢ Shortage of labour ➢ Unqualified workforce ➢ Nationality of workforce ➢ Low productivity level of workforce ➢ Personal conflicts among workforce

External factors	➢ Effects of surface conditions ➢ Delay in obtaining permits from municipality ➢ Hot weather effect on construction activities ➢ Rain effect on construction activities ➢ Unavailability of utilities on site ➢ Effects of social and cultural factors ➢ Traffic control and restriction at job site ➢ Accident during construction ➢ Differing site (ground) conditions ➢ Changes in government regulations and laws ➢ Delay in providing services from utilities ➢ Delay in performing final inspection and certification by third party

Source: Assaf and Al-Hejji (2004)

Table 3.3 Most Important Delay Factors According to Contractors

Type	Delay factor	Rank
Scheduling	Preparation and approval of shop drawings	1
Financing	Delays in contractor's progress payment by owner	2
Changes	Design change by owner during construction	2
Material	Delay due to special manufacture outside Saudi Arabia	4
Financing	Owner's cash problems during construction	5
Contractual relationship	Slowness of owner's decision making process	6
Material	Slow delivery of construction material	7
Changes	Design errors made by designers	7
Scheduling	Waiting for sample material to be approved	7

Source: Assaf and Al-Hejji (2004)

Table 3.4 Most Important Delay Factors According to Architectural Engineers

Type	Delay factor	Rank
Financing	Owner's cash problems during construction	1
Financing	Financing by contractors during construction	2
Contractual relationship	Relationship between different subcontractors' schedules	2
Contractual relationship	Slowness of owner's decision making process	2
Financing	Delays in construction progress payment by owner	5
Materials	Changes in type of construction materials	6
Scheduling	Poor judgment of people involved in estimating time	6
Contractual relationship	Controlling subcontractors by general contractors	6

Source: Assaf and Al-Hejji (2004)

Table 3.5 Most Important Delay Factors According to Owners

Type	Delay factor	Rank
Changes	Design errors made by designers	1
Government relationship	Excessive bureaucracy in project owner operation	2
Manpower	Shortage of labour	3
Manpower	Labour skill	3
Financing	Financing by contractor during construction	3
Material	Shortage of construction materials	6
Financing	Owner's cash problems during construction	6
Changes	Errors committed during field construction on site	6
Contractual relationships	Unavailability of professional construction management	6

Source: Assaf and Al-Hejji (2004)

3.1.4 Construction Delay: A Quantitative Analysis

Al–Momani (2000) undertook a study to determine the cause and extent of delays in public projects in Jordan. The study investigated the cause of delays on 130 projects, including residential buildings, office and administration buildings, schools, medical centres, and communication facilities. The sample population was established by selecting 130 finished public projects in different regions of Jordan between the years of 1990 and 1997. To investigate why construction delays and overruns occurred, the following data were obtained from the projects' records:

- Planned duration of contract
- Actual completion data
- Design changes
- Disputes
- Notifications
- Date of notice to proceed
- Delays encountered during construction
- Conflicts related to the drawings and specifications
- Time extensions
- Late delivery of material and equipment

As shown in Table 3.6 below, the frequencies for each delay in five different construction categories were provided, illustrating that projects were delayed for various reasons. The study found that the significant causes of delay were poor design, change orders, weather, site conditions, late delivery, economic conditions, and increase in quantities. The four main causes of delay were poor design, change orders and site and economic conditions.

Table 3.6 Summary of the Investigated Projects Frequency of Delay (Al–Momani, 2000)

Facility Type	**Poor Design**	**No Delay**	**Change Orders**	**Weather**	**Increase in Quantity**	**Late Delivery**	**Site Conditions**	**Economic Conditions**	**Total**
House	4	3	1	3	2	0	1	0	14
Office	8	5	5	4	5	1	2	4	34
School	10	14	8	6	3	4	5	2	52
Hospital	6	2	4	2	1	3	0	2	20
Roads	4	6	2	1	1	2	0	0	10
Total	32	24	20	19	12	10	8	8	130

3.1.5 A Comparative Study of Causes of Time Overruns

Chan and Kumaraswamy (1997) presented the results of a survey undertaken to determine and evaluate the relative importance of the significant factors causing delays in Hong Kong construction projects. The survey investigated 83 previously-identified project delay factors from the authors' pilot survey, and interviews with clients, consultants and contractors. The factors were grouped into eight major factor categories: project-related, client-related, design team-related, contractor-related, materials, labour, plant/equipment, and external factors. The following is a brief description of these categories.

1. Project–related factors include delays related to:
   - Project characteristics
   - Necessary variations
   - Communication among various parties
   - Speed of decision making involving all project teams, and
   - Ground conditions.
2. Client–related factors include those concerned with:
   - Client characteristics
   - Project financing
   - Client variations and requirements, and
   - Interim payments to contractors.
3. Design team-related factors consist of:
   - Design team experience
   - Project design complexity, and
   - Mistakes and delays in (producing) design documents.
4. Contractor–related factors comprise those related to :
   - Contractor experience in planning and controlling the projects
   - Site management and supervision
   - Degree of subcontracting, and
   - Contractor's cash-flow.
5. Materials factors include :
   - Shortages
   - Material changes

- Procurement programming, and
- Proportion of off-site prefabrication.

6. Labour factors encompass:
    - Labour shortages
    - Low skill levels
    - Weak motivation, and
    - Low productivity.
7. Plant/Equipment factors include:
    - Shortages
    - Low efficiency
    - Breakdowns, and
    - Wrong selection.
8. External factors comprise those such as:
    - Waiting time for approval of drawings and test samples of materials, and
    - Environmental concerns and restrictions.

The researchers' analysis of their data concluded that:

1. All three major groups of industry participants felt that poor site management and supervision, unforeseen ground conditions, slow speed of decision making involving project teams, client-initiated variations, and necessary variations of work were the five most significant sources of construction time overrun.
2. Despite some differing perceptions as to the relative importance of delay factors suggested by each group of respondents, there was general agreement between the client and consultants on a set of 10 principal factors, but the contractors only agreed with some of these.
3. The clients and consultants claimed that for the most part, the delays were attributable to a lack of contractor experience in planning and monitoring at the site.

Respondents' rankings of significant delay-causing factors are shown in Table 3.7.

Table 3.7 Respondents' Rankings of Significant Delay Factors

#	Cause of delay	Consultants	Contractors	Clients
1	Poor site management and supervisors	1	3	1
2	Unforeseen ground conditions	2	19	5
3	Client-initiated variations	3		
4	Low speed of decision making involving project team	4		
5	Necessary variations of work	5	13	6
6	Lack of communication between consultant and contractor	6	9	9
7	Inadequate control over site resource allocation	7		3
8	Delays in subcontractors' work	8	11	18
9	Inadequate managerial skills	9		2
10	Inadequate contractor experience	10	12	4
11	Inappropriate overall organisational structure	11	7	
12	Project construction complexity	12		11
13	Unsuitable management structure and style of contractor	13		
14	Low speed of decision making within each project team	14	15	20
15	Low level of communication between client and contractor	15		15
16	Slow information flow between project team members	16	20	
17	Unsuitable leadership style of contractor's manager	17		
18	Lack of communication between client and consultant	18	16	
19	Poor procurement programming of materials	19		16
20	Delay in design information	20	1	
21	Long wait for approval of drawings		2	
22	Unrealistic contract duration imposed by client		4	13
23	Mistakes and discrepancies in design documents		5	
24	Long wait for approval of test samples of materials		6	
25	Inadequate design team experience		8	
26	Low speed of decision making involving all project teams		10	12
27	Disputes and conflicts		14	
28	Shortage of material in market		17	17
29	Client-initiated variations		18	10

30	Poor site management and supervision			7
31	Shortage of skilled labour			8
32	Contractor's deficiencies in planning at preconstruction stage			14
33	Low labour productivity			19

3.1.6 Causes of Construction Delay: Traditional contract

Odeh and Bettaineh (2002) identified the major causes of delay in the construction industry and assessed the relative importance of these causes for the traditional adversarial type of contracts from the viewpoint of construction contractors and consultants. First, a survey questionnaire was developed to assess the perceptions of contractors and consultants of the relative importance of construction delay causes. Second, the questionnaire was distributed to a random sample of contractors and consultants working on large projects in Jordan. The survey is based on 28 well recognized causes of delay to which participants were asked to ascribe levels of importance. The causes were categorized into the following 8 major groups as shown in Table 3.8.

Table 3.8 – Relative importance index and ranking of delay factor (Odeh and Bettaineh 2002)

Category	Factor	Contractors		Consultants	
		Index	Rank	Index	Rank
Client	Finance and payment of completed work	3.30	4	3.32	2
	Owner Interference	3.51	2	3.21	4
	Slow decision-making by owners	3.24	8	3.16	5
	Unrealistically imposed contract duration	3.08	13	3.11	6
Contractor	Subcontractors	3.21	9	3.26	3
	Site management	3.29	5	2.58	13
	Construction methods	3.29	5	2.37	17
	Inadequate planning	3.14	10	2.37	17

	Mistakes during construction	2.56	17	2.74	11
	Inadequate contractor experience	3.37	3	3.37	1
Consultant	Contract management	3.10	12	3.00	7
	Preparation and approval of drawings	2.32	21	2.21	19
	Quality assurance/control	2.06	25	2.11	21
	Waiting time for approval of tests and inspections	2.46	18	2.47	15
Material	Quality of material	1.75	26	2.00	23
	Shortage in material	3.11	11	2.79	10
Labour and equipment	Labour supply	2.63	16	2.63	12
	Labour productivity	3.60	1	2.89	9
	Equipment availability and failure	3.25	7	2.42	16
Contract	Change orders	2.40	19	1.79	26
	Mistakes and discrepancies in contract documents	3.05	14	2.05	22
Contractual relationship	Major disputes and negotiations	2.94	15	2.16	20
	Inappropriate overall organization structure linking all parties to project	2.27	22	2.26	8
	Lack of communication between parties	2.38	20	2.53	14
External factors	Weather conditions	2.19	23	1.95	24
	Regulatory changes and building code	1.70	27	1.16	28
	Problems with neighbours	1.59	28	1.84	27
	Unforeseen ground conditions	2.10	24	1.84	25

3.2 SUCCESS FACTORS

A building project is completed through a combination of many events and interactions, planned or unplanned, over the life of a facility, with changing participants and processes in a constantly changing environment. Certain factors are more critical to a project's success than others. These factors are called critical project success factors. The term *Critical Success Factors* in the context of the management of projects was first used by Rockart in 1982 and is defined as those factors predicting success on projects.

Success is defined by Ashley et, al. (1987, p 71) as "results much better than expected or normally observed in terms of cost, schedule, quality, safety and participant satisfaction". The investigation of the success factors of construction projects has attracted the interest of many researchers and many studies have been conducted, with the aim of providing contract parties with valuable insight into how to consistently achieve superior results for their projects. Although construction projects are by their nature repetitive activities, each one has its own characteristics and circumstances. The following section investigates studies that identify critical success factors leading to successful completion of projects on time, within a planned budget, in the safest manner, and with the highest quality. These studies differ in the way they approach the problem and in the way the researchers evaluate success factors.

3.2.1 Determinants of Construction Project Success

Ashley et al. (1987) offer insight into factors that influence construction project effectiveness through interviews with construction project personnel and a literature review of relevant studies. Researchers started with a list of approximately 2000 success factors from previous studies and construction management personnel interviews, which they reduced to 46 success factors grouped into 5 major categories, as follows:

1. Management, organisation, and communication
2. Scope and planning
3. Controls
4. Environmental, economic, political, and social
5. Technical

In order to identify which of these factors had the most significant influence on construction project success, input from several construction project personnel was obtained. Each factor was subjectively rated using a range from *no influence* (rated with a value of 1) to *major influence* (rated with a value of 5). From these ratings the top 15 factors were grouped by their respective categories. From this list, 11 factors were chosen for further analysis. These are:

1. Planning effort
2. Project manager goal commitment
3. Project team motivation and goal orientation
4. Scope and work definition
5. Project manager capability and experience
6. Safety
7. Control systems
8. Design interface management
9. Risk identification and management
10. Technical uncertainty
11. Legal political environment.

Interviews were conducted to identify factors which:

- showed differences between average projects and outstanding projects;
- identified the principal measures of project success; and
- Identified factors showing a strong correlation to project outcome.

Eight companies were asked to submit an average project and one outstanding project. The individuals surveyed were experienced in project management covering a wide range of project types. Individuals were selected who had extensive experience with the project.

Response data from these interviews were analysed and the researchers found that the first seven factors were the most significant in determining project success. The others factors showed less distinction between average and outstanding projects, and therefore were probably not as important in determining the success of a project.

Likewise, success criteria were comparatively rated for average and outstanding projects, revealing that the most important criteria for gauging the success of a construction project were:

1. Budget
2. Schedule
3. Client satisfaction
4. Functionality
5. Project manager / team satisfaction
6. Contractor satisfaction

A final analysis of the correlation between particular factors and their influence on the success of a construction project was conducted. Results showed that differences in construction and design planning efforts best explained the delineation between average and outstanding projects. Interpretation of the results further showed that the following factors are most significant in determining project success:

1. Construction and design planning effort
2. Scope and work definition
3. Project manager goal commitment
4. Project team motivation goal orientation
5. Project manager capabilities and experience
6. Safety
7. Control systems

Most of the critical success factors identified are human-related factors. This is supported by Nguyen et al (2004) on the study on project success factors in large construction projects in Vietnam. Among 20 success factors researched, 5 critical success factors were identified. These were:

1. competent project manager
2. adequate funding until project completion
3. multidisciplinary/competent project team
4. commitment to project
5. availiability of resources.

The study also grouped the success factors into one of four components:

1. comfort
2. competence
3. commitment
4. communication

"Comfort" means ensuring that resources, efforts and leadership are well aligned for the implementation of projects. "Competence" requires having appropriate technology, experience, and specialities available for the project. "Commitment" ensures that all parties concerned with the project and all levels in the management hierarchy of each participating organisation are willing to manage, plan, design, construct and operate the facility harmoniously. "Communication" helps clarify and disseminate all necessary project information and status to all internal and external project stakeholders.

3.2.2 Critical Success Factors for Construction Projects

Chan (2004) reviewed previous works on empirical studies from seven major management journals to develop a conceptual framework on critical success factors (CSFs). Five major groups of independent variables were identified as crucial to project success. These are shown in Table 3.9.

Table 3.9 Factors affecting the success of construction projects (Chan, 2004)

Factors affecting project success	Variables
Project-related	➢ Type of project ➢ Nature of project ➢ Number of floors of the project ➢ Complexity of project ➢ Size of project Walker, (1995); Akinsola et al. (1997); Songer and Molenar (1997); Belout (1998); Chua et al (1999); Dissanayaka and Kumaraswamy, (1999); Kumaraswamy and Chan (1999)
Procurement-related	➢ Procurement method ➢ Tendering method

	Kumaraswamy and Chan, (1999); Walker (1997); Walker and Vines, (2000).
Project management-related	➢ Communication system ➢ Control mechanism ➢ Feedback capabilities ➢ Planning effort ➢ Developing an appropriate organization structure ➢ Implementing an effective safety program ➢ Control of sub-contractors works ➢ Overall managerial actions. Hubbard, (1990); Jaselskis and Ashley, (1991); Belout (1998); Chua et al. (1999); Walker and Vines, (2000).
Project participant-related (client, contractor, contractor, sub-contractor, suppliers, manufacturers)	➢ Client's experience ➢ Nature of client ➢ Size of client's organisation ➢ Client's emphasis on low construction cost ➢ Client's emphasis on high quality construction ➢ Client's emphasis on quick construction ➢ Client's ability to approve ➢ Client's ability to make decisions ➢ Client's ability to define roles ➢ Client's contribution to design ➢ Client's contribution to construction ➢ Project team leaders' experience ➢ Technical skills of the project team leaders ➢ Planning skills of the project team leaders ➢ Organizing skills of the project team leaders ➢ Coordinating skills of the project team leaders ➢ Motivating skills of the project team leaders ➢ Project team leaders' commitment to meet cost, time and quality ➢ Project team leaders' early and continued involvement in the project ➢ Project team leaders adaptability to changes in the project plan ➢ Project team leaders' working relationship with others ➢ Support and provision of resources Chua et al. (1999); Walker, (1995); Chan and Kumaraswamy, (1997); Songer and Molenar, (1997); Belassi and Tukel, (1996); Hassan, (1995).
External-related	➢ Economic environment ➢ Social environment ➢ Political environment ➢ Physical environment ➢ Industrial relations environment ➢ Technologically advanced Akinsola et al. (1997); Kaming et al.(1997); Songer and Molenar (1997); Chua et al. (1999); Walker and Vines, (2000).

Success in large-scale construction projects is a challenging matter and depends on several aspects which may include human-related factors, project management related factors, and factors related to the external environment. The study by Shamas-ur-Rehman Toor and Stephen O. Ogunlana (2007) agrees with this assertion, and notes that comprehension, commitment, competence, and communication are fundamental essentials for project success.

3.2.3 Checklist of Critical Success Factor for Building Projects

Sanvido et al (1992) defined the success of construction projects as the degree to which project goals and expectations are met. These goals and expectations may include technical, financial, educational, social, and professional aspects. The study by Sanvido et al (1992) covered all the project phases, including design, construction and maintenance. The researchers identified the success criteria list for each of the contract parties: owner, designer, and contractor. Some of the owner success criteria included being on schedule, being on budget, and return on investment. Examples of the designer success criteria were client satisfaction, quality architectural product, well-defined scope, and social acceptability. Finally, contractors' criteria for measuring success included meeting the schedule, profit, being under budget (savings obtained for owner and/or contractor), safety, and client satisfaction.

Furthermore, all three parties held similar viewpoints; for example, all agreed that the financial reality of doing business and achieving an appropriate schedule was a means of measuring the success of a project. On the other hand, there were some unique criteria. For example, the designer was looking for a project that would increase the level of professional satisfaction among their employees. Safety was a high priority for the contractor, and the owner was extremely interested in knowing that the building projects functioned properly for their intended use and were not affected by long-term defects or lingering maintenance problems. The study was also concerned with issues such as valid construction project success factors for building projects and whether these were the same or different in importance for different types of buildings, such as hospitals and office buildings.

A questionnaire was developed to facilitate data collection by the researchers and to ensure consistency in the elements examined. The study selected eight pairs of projects; the two projects in each pair were similar in scope and proposed by the same sponsor or company. One project was successful in the eyes of the sponsor and the second was less successful. The researchers made site visits to the selected projects and interviewed the principal engineers. The interviewee was asked to rank how successful the project was, and whether the function (such as facility team, experience, external constraints, resources, etc) had either positive or negative effects on the project's success. They were also asked what the effect was, what lessons were learned from the project, and what had been done to implement those lessons in subsequent projects.

The results of the research indicated that the following four factors were critical:

a) A well-organized, cohesive facility team to manage, plan, construct, and operate the facility.
b) A series of contracts that allowed and encouraged the various specialists to behave as a team without a conflict of interest or differing goals.
c) Experience in the management, planning, design, construction and operations of similar facilities.
d) Timely, valuable optimization of information from the owner, user, designer, contractor, and operator in the planning and design phase of the facility.

Sanvido et al (1992) determined the existence of a set of critical project success factors that play an important role in the planning, design, and construction of successful building projects. Parfitt and Sanvido (1993) used those success factors to develop a checklist that could be used by building professionals to predict the success of a project. An example of this checklist is:

Facility team:

- Have adequate steps been taken to assemble and build a facility team with the common goals and chemistry appropriate for this project?
- Is a sense of respect for the role and services of each team member evident?
- Is there an open and honest communication flow?
- Do all team members share a compatible philosophy with the owner of this project?

3.2.4 Critical Success Factors for Different Project Objectives

Chua et al (1999) identified critical success for construction projects based on the accumulated knowledge and judgement of experts in the industry. Sixty-seven success-related factors were considered and grouped under four main project aspects: project characteristic, contractual arrangements, project participants, and interactive process.

A questionnaire was developed to facilitate systematic data collection, and twenty experienced participants with an average of 20 years experience in the construction project industry participated in the study. The top 10 success factors based on the averages of budget performance, schedule performance, quality performance, and overall responses are displayed in Table 3.10.

The results of the study revealed that experts agree that there are different sets of construction success factors for different objectives. They determined that the probability of project success can be increased if the inherent characteristics of the project are thoroughly understood, appropriate contractual arrangements are adopted, a competent management team is assigned, and a sound monitoring and control system is established

Table 3.10 Critical Success Factors for Different Project Objectives: *(Chua et al, 1999)*

Success factors	**Budget**	**Schedule**	**Quality**	**Overall**
Adequacy of plan and specification	1	1	1	1
Constructability	2	2	2	2
Project manager commitment and involvement	8	3	4	3
Realistic obligations and clear objectives	3	6	5	4
Project manager competency	5	4	6	4
Contractual motivation and incentive	9	5	10	6
Site inspection	-	10	3	7
Construction control meetings	-	8	7	8
Formal communication	-	-	8	9
Economic risks	3	-	-	9

3.2.5 Success Factors In the Construction Process

Cooper et al (2001) reviewed literature identifying success factors on generic projects and construction projects (Avots, 1969; Baker et.al., 1988; Barnes and Wearne, 1993; Beale and Freeman, 1991; Bedelian, 1996; Bentley and Raftery, 1992; Cash and Fox, 1992; Chan, 1992; Chua et.al.,1997; Clarke, 1999; CRT, 1995; Graham, 1988; Hensey, 1991; Hughes, 1986; Kothari, 1986; Pinto and Slevin, 1987; Pinto and Slevin, 1988). The research identified several success factors for the construction process as follows:

Clarity/ Definition of project objective

- To state clearly the expected end result, with consultation with the related parties. Although each party might have different specific goals in mind for the project, they must spell out their goals.
- To state the communicated and defined goal to all parties.
- To state the clarified time and cost objectives.

Scope of project

- To state the general direction and define the client's requirement.
- To present a clear design brief with minimal subsequent changes. A brief must be exact and owned by the client at the highest (strategic) level within the client and project organisations.

Project manager

- The Project Manager is the key person in the project. They must demonstrate multi-dimensional abilities including interpersonal, technical and administrative skills.
- The most important element is that the project manager must clearly understand their role as project leader, clearly defining their extent of involvement, and the authority and control they exercise over personnel.
- Personality – the project manager must have a personality which encourages respect from team players, associates and peers.
- Leadership – the project manager should have leadership skills and be able to apply competent managerial skills. The project manager should have the ability to persuade other members of the group to their view, and be able to resolve conflict between parties.
- Organizing – the project manager should be responsible for organizing, selecting and defining the responsibilities of the project team.
- Coordinating – the project manager should identify interfaces between the activities of the functional departments, subcontractors, and other project contributors.
- Controlling – the project manager should be responsible for monitoring progress, identifying problems, communicating the status of interfaces to contributors, and initiating and co-coordinating corrective action.
- Motivating – the project manager should motivate the project team to perform their duties, and also convince the project team to co-operate with each other.
- Technical knowledge and experience – the project manager must possess good technical knowledge and experience, since most of the project is highly technical.

Project Team Commitment

- All participants must understand and be dedicated and strongly committed to achieve, maintain and fulfil project goals.
- All participants must be committed to the concept of project planning and control and must be able to put the concept into practice. They must understand the project management process, its purpose and values, and be committed to following the steps and necessary procedures.

Capability

- All participants must possess adequate capabilities, including skills and experience.
- All participants must retain appropriate interpersonal skills.

Cooperation

- All participants must maintain a good working relationship between the client, the project team members and stakeholders.
- All participants must sustain a healthy work attitude.

Planning

- The plan, or schedule, should be prepared as early as possible.
- The plan should be prepared with as much detail as possible, including during the design process and throughout its phases. The detail required includes individual actions for project implementation, the party responsible for each action (if known), and the technical standard required.
- The plan should be realistic; it should identify the appropriate workload for the project team.
- The plan must be updated regularly in order to keep pace with the project's development.
- The team should be prepared to re-plan the job schedule to accommodate frequent changes on dynamic projects.
- The team should incorporate detailed planning guidelines for termination.

Control

- Schedule control – the project's managers and supervisors should jointly agree on intermediate milestones and build the detailed schedule around these. Successful project teams mark the achievement of milestones formally (for example by celebrating) in order to break the monotony of a long schedule into easily managed portions.

- Costs control – focus on tracking the money spent. This requires detailed actual costs, and one of the best monitoring aids is a plot of plan versus actual costs on a cash-flow curve, for example, an earned – value analysis system.
- Quality control – focus on ensuring the project reaches the agreed and designed level of quality. It must be closely scrutinised during the entire process.
- Methods of control include regular meetings and day-to-day reports etc.

Appropriate size of work package

- Divide the project tasks into appropriate sizes and identify the relevant parities responsible for each task.
- Maintain the appropriate level of staff for the amount of work that needs to be done.

Communication and information management

- Instigate and maintain adequate communication channels among the project team.
- Ensure there is some way to manage the flow of information. The suggested methods of transferring information should include drawings, manuals, meetings and letters.

Top management support

- Provide the necessary resources, authority and power for performing the project.

Environment

- Consider the natural environment e.g. weather.
- Consider sustainability, e.g. supply of materials.
- Consider the political environment, e.g. the legal requirements of the regulatory authorities.

Health and safety

- Ensure legislative health and safety requirements are considered.

3.2.6 Critical Success Factors over the stages in the project life cycle

Slevin and Pinto (1986, 1987) identified ten critical factors relating to project implementation success. The ten factors are:

1. ***Project Mission***. The initial clarity of goals and the general direction
2. ***Top Management Support***. Willingness of top management to provide the necessary resources and authority/power for project success.
3. ***Project Schedule/Plan***. A detailed specification of the individual action steps required for project implementation.
4. ***Client Consultation***. Communication, consultation, and action on behalf of all impacted parties.
5. ***Personnel***. Recruitment, selection, and training of the necessary personnel for the project team.
6. ***Technical Tasks***. Availability of the required technology and expertise to accomplish the specific technical steps.
7. ***Client Acceptance***. The act of “selling” the final project to its ultimate intended users.
8. ***Monitoring and Feedback***. Timely provision of comprehensive control information at each stage in the implementation process.
9. ***Communication.*** The provision of an appropriate network and necessary data to all key actors in the project implementation.
10. ***Trouble-Shooting***. Ability to handle unexpected crises and deviations from plan.

Pinto and Prescott (1988) have investigated the relationship between the project life cycle and behavioural issues. The initial stage of conceptualisation refers to the time frame at which a strategic need has been recognised by top management. The second stage is planning, whereby formal plans to accomplish the initial goals are established. The third stage is execution, during which the work of the project is performed. The fourth and final stage is the termination stage. Once the project is completed, resources assigned to the project must be released, personnel from the project team are usually reassigned to other duties, and the project is transferred to its intended users.

Pinto and Prescott (1988) used a stepwise regression on the critical success factors at each of the four stages in the project life cycle. The results demonstrated that though there is empirical justification for several of the previously listed critical success factors, the relative importance of various critical success factors are subject to change at different phases of the project implementation process. The finding implies that future use of critical success factor analysis and implementation, regardless of the area to be examined, may be contingent on other organisational phenomena, such as project (or organisational) life cycle. Further, the practicing project manager would be in a better position to assist in the implementation of a project, given an increased awareness of the factors most critical to success at specific life cycle stages.

3.3 CONCLUSION

DELAY FACTORS

The literature review of the delay factors was used to build a comprehensive list of delay causes. It was noted in Table 3.2 that the Assaf and Al-Hejji (2004) study has the largest number of delay causes (73 causes). These were grouped into nine major groups: project-related factors, owner-related factors, contractor related factors, consultant-related factors, design team-related factors, materials, equipment, labour and external factors. Based on the preliminary studies and discussion with owners, contractors and engineers, some of the delay factors listed by Assaf & Al-Hejji are not common, not applicable, have a rather low effect on project duration and were not seen as a determinant factor of project delay in Brunei's construction industry.

Odeh and Bettaineh (2002) identified the major causes of delay in construction industry building projects using 28 well recognized construction delay factors. These causes were categorised into the following eight major groups: client-related factor, contractor, consultant, material, labour and equipment, contract, contractual relationship and external factors. The causes of delay identified by Odeh and Bettaineh (2002) were chosen for this research. Firstly, Odeh and Bettaineh identified the major causes of delay in the construction industry and assessed the relative importance of these causes for the traditional adversarial type of contracts. Secondly, the factors identified by Odeh and Bettaineh are more common to building construction processes. The study is also supported by other researchers such as Shamas-Ur-Rehman Toor and Stephen O.Ogunlana (2008) and Nguyen et al (2004). The 28 causes of delay were seen to fit this research study as the research is focused on the building construction process for the traditional adversarial type of contracts. These delays are also common to Brunei's construction industry.

SUCCESS FACTORS

Ashley et al. (1987) compiled 2000 success factors based on informal interviews of construction professionals. The list was reduced to 46 factors and grouped into 5 major categories. These are: management, organisation and communication; scope and planning; controls; environmental, economic, political and social; and technical. A further analysis by construction project personnel to identify which of these factors had the most significant influence on construction project success reduced the list to 11 factors. A final analysis identified the 7 most significant factors in determining project success.

There are number of studies on success factors in the construction industry. Chua et.al (1999), Cooper (2001), Alkathami (2004), and Jha and Lyer (2008) adopted the success factors identified by Ashley et al (1989). It can be seen that critical success factors have been predominantly contributing towards enhancing the performance level and success of projects.

Due to its comprehensive, detailed descriptions, and because much of the other research was based upon it in some way (Chua et.al (1999), Cooper (2001), Alkathami (2004), Jha and Lyer (2008), Nguyen et al (2004), Shamas-ur-Rehmen Toor and Stephen O.Ogunlana (2008)), the seven most significant success factors in determining project success identified by Ashley et al. (1987) have been chosen for further investigation in this study. These success factors are:

1. Organisational planning effort
2. Project manager goal commitment
3. Project team motivation
4. Project manager technical capabilities
5. Scope and work definition
6. Control systems
7. Safety

CHAPTER 4

RESEARCH METHODOLOGY

This chapter investigates current research approaches with a view to selecting the most appropriate methodology for the current research project, including the research strategy and justification of the methodology, the procedure used, and sample selection. This research study:

- requires a methodology to investigate variables and scales to represent happenings;
- uses statistical analysis for personal interpretation; and
- 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 research requirements. A quantitative methodology also aligns with the fact that the majority of the research undertaken in construction management, engineering and property uses quantitative methodologies.

4.1 RESEARCH STRATEGY

The term *research* refers to the development a new body of knowledge. Scientific research refers to the systematic, controlled, rigorous, empirical and critical investigation of a hypothetical proposition about a presumed relation in order to find the solution to a problem or discover and interpret new knowledge (McCuen, 1996). McCuen (1996) describes scientific research as being the investigation of phenomena via practices consistent with the method of science.

Scientific investigation and the verification of beliefs about real world phenomena involve empirical research based on the belief that all knowledge originates in experience (Stone, 1978). The research presented in this thesis deals with facts that have objective reality, and based on this empirical research is the process used in this study. The empirical scientific research cycle (McCuen, 1996) in Figure 4.1 shows the basic steps for the empirical study of a phenomenon.

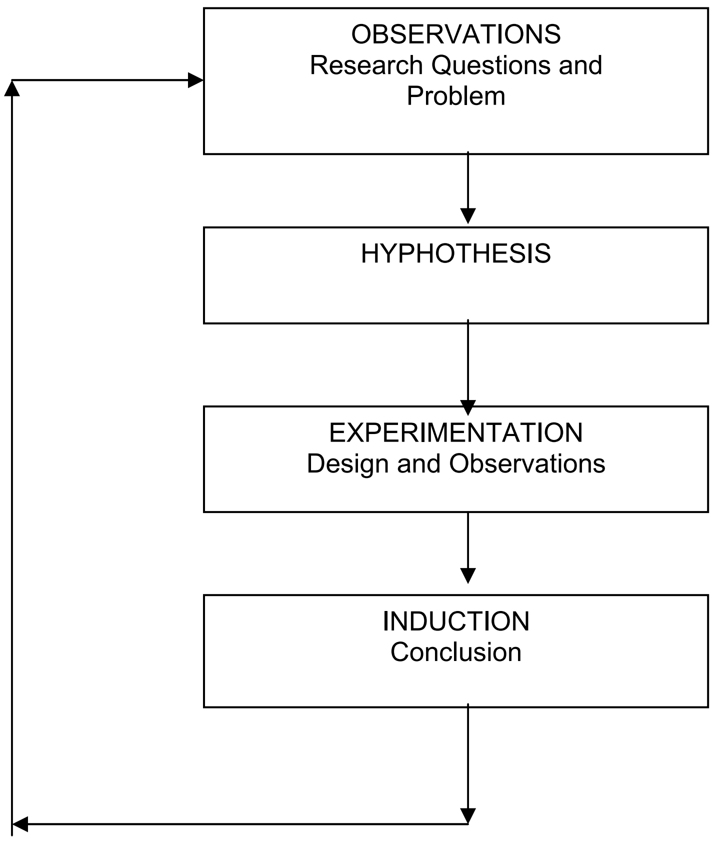


Figure 4.1 The Empirical Scientific Research Cycle (adopted from McCuen 1996 and Stone 1978)

- Observation: an informed and critical questioning of an existing phenomenon leading to a problem statement and the research question.

- Hypothesis: a formal expression of a preconceived factual relationship which provides a tentative explanation or solution to the problem.
- Experimentation: the design of the study leading to a systematic and controlled testing of the hypothesis.
- Induction: a generalisation of the experimental results to a formal statement of the theory.
- Empirical research has a number of different approaches to research strategies. An example of empirical strategies is shown in Figure 4.2.

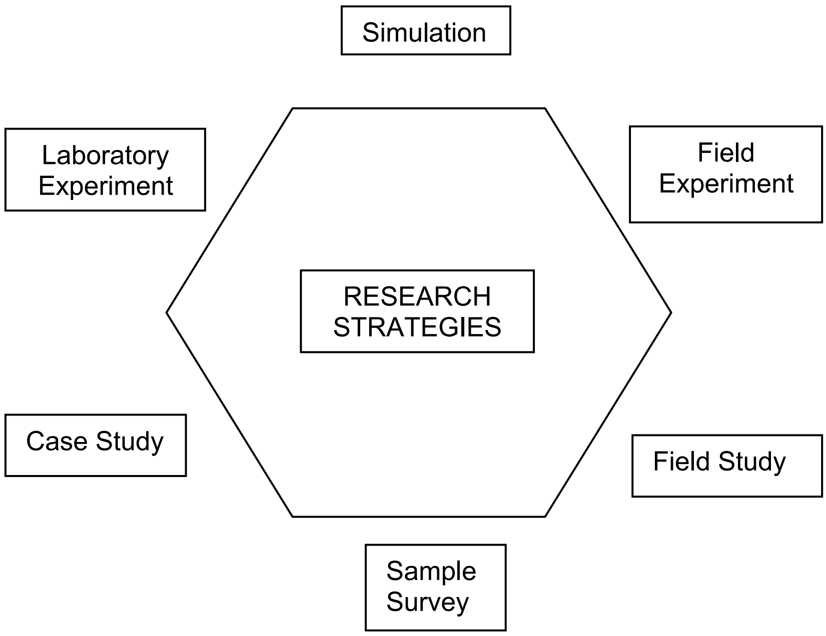


Figure 4.2 Empirical Research Strategies (adopted from Stone 1978)

Yin (2003) points out that a research strategy is not distinguished by the following hierarchy:

- Case studies are appropriate for the explanatory phase of an investigation
- Surveys are appropriate for the descriptive phase
- Experiments are the only way of developing explanations for casual inquiries

But by conditions such as the:

- Type of research question posed
- Extent of control that an investigator has over actual behavioural events
- Degree of focus on contemporary as opposed to historical events.

The research questions for this study are:

1. What are the real causes of project delays in the Brunei building construction industry?

2. How are these delay factors correlated to critical success factors within the construction industry?

The type of research question and the variables involved in the research will differentiate the various strategies available to the researcher. Table 4.1 shows the conditions for various research strategies.

Historical research is concerned with historical events or an approach to contemporary events or problems. Historical research can also be used to help solve problems through an examination of what has happened in the past (Bennet, 1991). The case study examines contemporary events, especially when the relevant behaviour of the phenomenon being studied cannot be manipulated, as it can in experiments. Unlike historical research, the case study has two sources of evidence: direct observation and systematic interviewing.

Table 4.1 Relevant Situations for Different Research Strategies (Source: adopted from 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 case study was identified to be the most appropriate methodology to answer the research questions identified in Chapter 1. This is due to its ability to deal with a variety of evidence such as artefacts, observations, documents and interviews. To conduct the research, the data collection method selected is the survey, which will identify the delay factors and examine the correlation of the critical success factors and the delay factors. Finally a group consensus Delphi method is selected to rank the most critical success factors for Brunei building construction to improve project performance.

4.2 THE SURVEY STRATEGY

The survey is a very popular method of gathering information as it allows inputs from various sources such as clients, key informants, and target populations, and it helps to build consensus solutions (McKillip, 1986). The survey strategy involves research in which:

- Sample surveys were selected to represent a known population. The sampling survey allows the researcher to generalise a study's result to a known population.
- Data are collected directly from respondents using a systematic technique (e.g. questionnaire or interviews);

- The researcher manipulates no independent variables;
- The setting in which data is obtained is natural;
- Responses of subjects are assumed to be largely unaffected by the context in which they are elicited;
- Influences of confounding variables are controlled statistically; and
- The purposes of the research may range from exploration of phenomena to hypothesis testing.

Instruments should be initially piloted to small numbers of respondents to verify whether the questions are easy to understand, appropriate to the research topic, unambiguous (Fellows and Liu, 2003), and to gain some idea of the time required to administer the questionnaire. It is also important to get feedback and input on other important issues that may be worthy of consideration, that the initial instrument may have missed. This also gives the researcher an indication of whether the instrument is measuring the right concept, hence its validity and reliability.

The advantages of survey strategies (as adopted from Stone, 1978) are;

- The sample is chosen in such a way as to allow for generalisations to a defined population;
- Results are accurate because of a large sample size and generally low sampling error;
- Random sampling procedures reduce or eliminate problems of sample bias;
- Data collection takes place in a 'natural ' setting;
- Data is obtained directly from respondents;
- Surveys often yield data that suggests new hypotheses;
- If mailed questionnaires are used to collect data, the cost of data per subject is relatively low (compared, for example, to interview data); and
- A variety of systematic data collection methods (e.g interviews, questionnaires and observation) can be used alone or in combination.

Disadvantages include:

- Decreased willingness and refusal of people to respond to sample survey probes, because of suspicion, fear and other forms of resistance;
- Most surveys are 'one shot'; as a result their capacity for generating data to test causal connections among variables is limited;
- In terms of total costs, the sample survey is an extremely expensive research strategy because of large administrative and personal costs;
- The standardised response formats of many sample survey measures (e.g. questionnaire and structured interviews) may force respondents to subscribe to statements they don't fully endorse;
- If questionnaires are used to collect data, the proportion of returned questionnaires may be low.

Two types of surveys (other than interviews) were used as data collection instruments in research undertaken by Ashley et al (1987) and Assaf et al (1995). The target populations interviewed or surveyed were either related to a specific project (as in the research by Ashley et al., 1987) or came from general experience (as in the research by Assaf et al., 1995). In this study it is proposed to use both of these data collection techniques, thereby creating two types of surveys. A specific survey will be created to collect data from owners, engineers or contractors - and a general survey will be used to gather information regarding individuals' experiences with projects generally.

The specific survey will obtain recollections of exact field experiences from the project engineers. The target populations for this survey were owners and contractors, or their representatives who were involved in Brunei building construction projects. These projects must have been nearly completed, or completed within the last seven years, and in order to gather necessary technical data, respondents were required to be project managers.

The second version of the survey is the general survey which will gather opinions in a manner similar to the specific project survey. The target population is any engineer who worked or has been working in the Brunei construction field for at least the past ten years, and owners who have experience in building construction projects.

4.3 CONSENSUS-FORMING TECHNIQUES

The methodology in this research requires the use of consensus-forming techniques. This section of the thesis will briefly outline the varieties of consensus-forming techniques and present the rationale for the use of the Delphi technique.

The opinions of experts are needed as an input in many policy arenas in which objective data is unavailable and subjective judgements play a significant role. Given that individual experts may hold widely varying opinions, it is logical to seek a consensus of opinions from a panel of experts. The value of consensus-forming techniques is based on the assumption that the opinions of a group of experts will be more accurate than the opinions of individual experts, correcting for individual bias and misinformation. Group consensus can be obtained in a variety of ways, three of which will be discussed here. These are:

- The interacting group process;
- The nominal group process; and
- The Delphi process.

4.3.1. Interacting Group Process

According to Delbecq (1968), the interacting approach to committee decision-making is defined as a group meeting in which all communication acts take place between members with minimal control or formal structuring. The process of decision-making in the interacting group is:

1. Unstructured group discussion to obtain and pool ideas of participants;
2. Majority voting on priorities by hand counting.

4.3.2. The Nominal Group Process

Originally developed as an organisational planning technique by Delbecq, Van de Ven and Gustafson in 1975, the nominal group technique is a consensus planning tool that helps prioritise issues (Delbecq et al, 1986). In the nominal group technique, participants are brought together for a discussion session led by a moderator. The nominal group technique has been used as an alternative to the focus group and the Delphi techniques. It presents more structure than the focus group, but still takes advantage of the synergy created by group participants.

As its name suggests, the nominal group technique is only nominally a group, since the rankings are provided on an individual basis. The nominal group technique involves a process similar to the Delphi method (Dalkey, 1968) with the objective of the technique being the exploration of ideas for decisions from a team of experts (Adler and Ziglio, 1996). The prime difference between NGT and the Delphi technique is that communication does take place between participating individuals within the NGT method. As well, NGT separates out the process of independent ideas generation, structured feedback, evaluation and aggregation of opinions. It increases individual participation. Detailed research by Gustafson et al (1973) showed NGT was superior to Delphi by demonstrating the following advantages:

- Voting was anonymous
- There were opportunities for equal participation of group members
- Distractions (communication noise) inherent in other group methods were minimised.

The nominal group process is a structured group meeting in which individuals work in the presence of others, but do not verbally interact for a period of time. The nominal process follows a prescribed sequence of problem-solving steps (Delbecq and Van de Ven, 1971), namely:

1. Silent generation of ideas in writing;
2. Fixed cyclic order of presentation and recording of independent ideas on a blackboard or flip-chart;
3. Discussion and clarification of ideas; and
4. Independent ranking of priorities.

The use of face-to-face meetings to reach agreement sometimes causes problems because:

- A senior member of the group (e.g. a boss or person with a dominant personality) could sway opinions in a manner inconsistent with the information presented.
- People could be unwilling to change opinions when stated publicly
- People could grandstand or posture by sticking to beliefs that may not have been appropriate, and so show they are actively engaged in the process.

4.3.3 The Delphi Process

The unique strengths of Delphi as a forecasting, planning, and decision making tool sustains the popularity of this technique. It relies on a structured, yet indirect, approach to quickly and efficiently elicit 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. Helmer (1983) agreed that Delphi is a technique frequently used for eliciting consensus from within a group of experts that has application in reliability and has many advantages over other methods of panel decision making. Helmer (1983) agrees with Linstone and Turoff (1975) in regards to the application of Delphi. Helmer (1983), Linstone and Turoff (1975), and Dalkey (1972) all found that one of the major advantages of using Delphi as a group response is that consensus will emerge with one representative opinion from the experts.

Dalkey (1967) identified the basic characteristics of the Delphi technique as anonymity, and controlled feedback from the interaction and statistical group response. These characteristics are as follows:

1. Anonymity – the responses from questionnaires or other communication, from specific members of the panel, are not identified and anonymity is maintained. Anonymity reduces the effects of dominant individuals, which often is a concern when using group-based processes to collect and synthesize information.

2. Controlled feedback from the interaction – controlled feedback allows interaction with a large reduction in discord among panel members. Multiple interactions among group members in several stages result in the subjects becoming more oriented to problem-solving, offering their opinions more insightfully, and minimizing the effects of communication in a group process.

3. Statistical group response – the group opinion is defined as a statistical average of the final opinions of the individual members, with the opinion of every group member reflected in the final group response. The use of statistical analysis will reduce the potential of group pressure for conformity; analysis can ensure the results of the generated opinions of the individual members are well represented in the final iteration.

The Delphi technique, due to its flexibility, is best suited to the exploration of issues involving a mixture of scientific evidence and social values (Webler et al, 1991). Mohapatra et al (1984) suggest that a Delphi study is usually directed to four broad categories of issues. These are:

- Normative issues such as ‘goal setting’;
- Narrative issues such as ‘problem statements’;
- Predictive issues such as forecasting occurrence of new events and forecasting point values and trends of key parameters; and
- Suggestive issues such as developing causal models and formulating new policies.

Many different types of Delphi survey techniques have been developed. However they have several common distinguishing features:

- They elicit the views of panels of experts;
- They employ an iterative process of summarising, averaging and recycling panel members' views to encourage convergence on a consensus view;
- Participants are given the opportunity to revise earlier answers in light of the general opinions expressed by the group as a whole;
- Information is collected by questionnaire and does not involve interviews or discussions; and
- Members of the panel are guaranteed anonymity.

The process for each type of the Delphi is essentially the same, and involves an interaction between members of the group (Delphi panel) and researcher, with the researcher acting as facilitator. Theoretically the process can be continuously iterated until consensus is achieved at the desired level. The sufficient time required to collect information and reach a consensus in many cases is up to three iterations (Worthen and Sanders, 1987; Brooks, 1979).

Fowles (1978) describes the following ten steps for the Delphi Method:

1. Formation of a team to undertake and monitor a Delphi on a given subject.
2. Selection of one or more panels to participate in the exercise. Customarily, the panellists are experts in the area to be investigated.
3. Development of the first round Delphi questionnaire.
4. Testing the questionnaire for proper wording (e.g. ambiguities, vagueness)
5. Transmission of the first questionnaires to the panellists.
6. Analysis of the first round responses
7. Preparation of the second round questionnaires (and possible testing).
8. Transmission of the second round questionnaires to the panellists.
9. Analysis of the second round responses (Steps 7 to step 9 are reiterated as long as desired or necessary to achieve stability in the results.)

10. Preparation of the report by the analysis team to present the conclusions of the exercise.

Brooks (1979) included an additional step prior to beginning the procedure to assess the willingness of potential panel members to participate in the study. Several steps identified by Brooks (1979) in using the Delphi Technique are:

1. Identifying the panel of experts.
2. Determining the willingness of individuals to serve on the panel.
3. Gathering individual input on the specific issue and then compiling it into basic statements.
4. Analysing data from the panel.
5. Compiling information on a new questionnaire and sending this to each panel member for review.
6. Analysing the new input and returning to the panel members the distribution of the responses.
7. Asking each panel member to study the data and evaluate their own position based on the responses from the group. When individual responses vary significantly from that of the group norm, the individual is asked to provide a rationale for their differing viewpoint while limitations are placed on the length of the remarks in order to keep responses brief.
8. Analysing the input, and sharing the minority supporting statements with the panel. Panel members are again asked to review their position and if not within a specified range, to justify the position with a brief statement.

The Delphi method avoid the pitfalls of face-to-face interaction, such as group conflict and individual dominance which make it a popular technique for data collection where more individuals are needed than can effectively interact in a face to face exchange. Linstone and Turoff (1975) see an important role for the Delphi method, where the number of specialists is too large and too little time and funds are available to organise group meetings to effectively interact in a face to face exchange.

The Delphi method is beneficial where there is no historical data of adequate communication. The strength of the Delphi method to collect data from individuals or relevant specialists may contribute diverse backgrounds with respect to expertise and experience. It is also one of the best known methods for dealing with open ended and creative aspects of a problem because it motivates independent thought and gradual formation of group solutions. The technique is also relatively inexpensive and simple. Design, implementation and analyses of a Delphi do not need advanced mathematical skills. Due to its inexpensive techniques, it is appropriate to use where time and cost make frequent group meetings unfeasible.

Another of the strengths of Delphi is its flexibility to allow individuals to respond at times suitable to them. Where a Delphi study consists of a large number of statements, more time is required to complete the questionnaires. Delbecq et al. (1975), Ulschak (1983), and Ludwig (1994) recommend that administration of a Delphi study requires a minimum of 45 days. Delbecq et al. (1975) recommend the time required between iterations to respond to each round of Delphi is two weeks. This flexibility allows individuals, who may be restricted by daily schedules and geographic location, the opportunity to respond at times available to them. There are many additional advantages. The technique is simple to use. Advance mathematical skills are not necessary for its design, implementation, and analysis. Because the Delphi provides confidentiality, many barriers to communication are overcome. Some of these barriers are reluctance to state unpopular views, to disagree with one’s associates, or to modify previously stated positions (Barnes, 1987).

However the Delphi study also has some limitations. These weakness include conceptual and methodological inadequacies, poor selection of expert panels, potential for sloppy execution, poorly designed questionnaires, little feedback, questionable consensus, unreliable results analysis, and instability of responses among consecutive Delphi rounds. Another disadvantage of Delphi is that ‘it is difficult to establish the true subjective probabilities of each panellist, something that can be done only over a long sequence of identical experiments, the very idea of which is incompatible with the justification of the Delphi in the first place.' Also, panellists can inadvertently or deliberately promote desired outcomes or influence future decisions thus raising questions about the use of group consensus as a stopping criterion (some of these weakness are inherent in other qualitative forecasting techniques as well).

Another disadvantage of the Delphi study is the lack of criteria for distinguishing an expert from a novice and the lack of sufficient evidence that the judgement of experts is more reliable than that of novices or that group opinion is always superior to individual opinion. According to Linstone and Turoff (1975), the virtual problems do not affect the utility of Delphi but rather how to select the respondent group. Fortune (1992) suggests one of the problems arise when the panel members chosen are so close to the problem that they cannot see the future; this may result in Delphi failure, as the panel members may not be able to see the vision or the big picture in which they are involved.

Linstone and Turoff (1975) identified the Delphi technique as one form of anonymously eliciting the opinions of experts concerning events, and the reasoning behind the opinions. Sackman (1972) identified important shortcomings in the Delphi technique which were important in considering this form of elicitation. These shortcomings are:

- Information and questions provided to experts needed to be carefully reviewed to ensure objectivity.
- Difficulty in summarising and presenting a common evaluation scale to a group that could be interpreted uniformly by the experts.
- Benefits of experts participating in active dialogue may be missed.
- Difficult and time consuming to explore disagreements between experts.

The shortcoming and weakness of the Delphi technique to be considered when using Delphi method are:

- Potential for low response rates
- Consumption of large blocks of time
- .Potential for moulding opinions
- Potential for identifying general statements vs specific topic related information.

In the Delphi process, data analysis can involve both qualitative and quantitative data. Qualitative data from the Delphi studies deal with open-ended questions to solicit subjects' opinions, which are conducted in the initial iteration. The iterations' technique is to identify and hopefully achieve the desired level of consensus as well as any changes of judgements among panellists. Hasson, Keeney, & McKenna (2000) note that the major statistics used in Delphi studies are measures of central tendency (mean, median, and mode) and level of dispersion (standard deviation and inner-quartile range) in order to present information concerning the collective judgements of respondents. Generally the use of median and mode are favoured. However in some cases, as reported by Murray and Jaman (1987), the mean is also workable.

4.3.4. Comparisons of the Different Processes

Riggs (1983) argues that group decision-making with interactive groups inhibits creative thinking. The nature of inhibiting influences, which act to reduce the performance of interacting groups in problem solving, seem to relate to the following (Taylor et al, 1958):

- The inevitable presence within most organizational groups of status incongruities, wherein low-status participants may be inhibited and go along with opinions expressed by high-status participants, even though they feel their opinions are superior,
- The influence of dominant personality types upon the group; and
- Tendencies to reach speedy decisions before all problem dimensions have been considered due to meeting time constraints.

The nominal group process facilitates creative decision-making more than conventional interacting groups. This is due a number of characteristics of nominal groups (Delbecq and Van de Van, 1971). Nominal group techniques:

- Provide each individual with the time and opportunity to engage in reflection, and force participants to record their thoughts; and
- Allow all participants to share in the opportunity to influence the direction of group decision outcomes.

The Delphi process tends to avoid the pitfalls of an interacting group and, simultaneously, contains most of the positive characteristics of the nominal group process. The major differences between nominal and Delphi approaches to decision-making are:

- Delphi respondents are anonymous to one another, while nominal group members become acquainted with one another; and
- Nominal groups meet face-to-face around a table, while Delphi respondents are physically distant and never meet.

All communications among respondents in the Delphi process occur via written questionnaires. In nominal groups, communications occur directly between members and the leader.

4.4 DELPHI METHOD - RANKING THE CRITICAL SUCCESS FACTORS

One of the main objectives of this research study is to rank the most important critical success factors for Brunei building construction projects. This requires an expert panel to perform the ranking. The Delphi method provides the researcher with a flexible and adaptable tool to gather and analyse data. The Delphi technique is adopted as it is beneficial and useful for the researcher for the following reasons:

1. The problem does not lend itself to precise analytical techniques but can benefit from subjective judgements on a collective basis.
2. The individuals needed to contribute to the examination of a broad or complex problem have no history of adequate communication in this

area, and may represent diverse backgrounds with respect to experience and expertise.

3. Delphi is a qualitative technique that achieves group consensus while avoiding the hazards of face-to-face interactions, such as group conflict and individual dominance (Rowe et al 1991). As the expert panel are mainly composed of policy makers, this is a very important reason for electing to use the Delphi method. In the governments of developing countries, there are inter-ministerial, personal and departmental rivalries (e.g. central bank governor, finance minister, and planning agencies are often conflicting, rather than cooperating, forces) (Alam,1990).
4. Time and cost make frequent group meetings unfeasible. Waissbluth and Gotari (1990) undertook research in Mexico using the Delphi technique to overcome some of the shortcomings observed in planning, and offer a viable alternative to national or sectoral planners. This study showed that high-ranking officials and researchers can be part of the planning process without giving up much of their valuable time.
5. Disagreements among individuals are so severe or politically unpalatable that the communication process must be referred and/or anonymity assured. In the Delphi process, experts give their opinion without publicly admitting that they have done so, thus encouraging them to express a more personal viewpoint rather than a cautious institutional position (Masser and Foley, 1987).
6. The heterogeneity of the participants must be preserved to assure the validity of the results, i.e. avoidance of domination by quantity or by strength of personality (Linstone and Turoff, 1975).
7. Finally, Delphi is one of the most popular forecasting techniques for technological and industry-wide forecasting and it is estimated that 90% of technological forecasts and studies are based on Delphi (Yuxiang et al, 1990).

The design and implementation of the Delphi process for this research considers two areas: subject selection and the time frames prior to initiating the study. Additional precautions concern low response rates, unintentionally guiding feedback, and surveying panellists about their limited knowledge of the topic rather than soliciting their expert judgements.

Therefore, the Delphi process designed for this research is as follows:

- Identify a team to undertake and monitor a Delphi on a given subject.
- Select one or more panels - whose consensus opinions are sought - to participate in the exercise. Typically, the panellists are experts in the area to be investigated.
- Determine the willingness of individuals to serve as a panel.
- Develop the first round Delphi questionnaire.
- Test the questionnaire for proper wording (e.g, ambiguities, vagueness).
- Compile information for the first questionnaire and send this to the panellists.
- Analyse the input of the first round responses and return these to the panel members.
- Have each member of the panel rate or rank the result from the first questionnaire. This is the second round questionnaire.
- Analyse the second round responses (another round of questionnaires are reiterated as long as desired or necessary to achieve stability in the results).
- Present the result of questionnaire two in the form of questionnaire three showing the level of consensus. Where the individual differs substantially from the group, and chooses to remain so, the respondent should provide a brief reason or explanation.
- Preparation of the report by the analysis team to present the conclusions of the exercise.

Experts are qualified through their knowledge skill, experience, training or education; therefore, criteria used to select the experts for this research are as follows:

- Experience with and contribution to the local and other regions of the construction industry;

- Knowledge of local capabilities;
- Some knowledge of critical success factors;
- Experience of construction and economic activities.

4.5 THE RESEARCH PROCEDURE

The research procedure for this thesis includes the following:

- A clear definition of the problem being studied
- The research objectives of the study
- Justification of the research and description of the research
- Identification of issues relating to the research investigations
- Study of the components and elements that comprise the investigation
- Description of methodology for the research investigation.

Figure 4.3 presents the main activities of this investigation which provides an explanation of the research process based on the research plan.

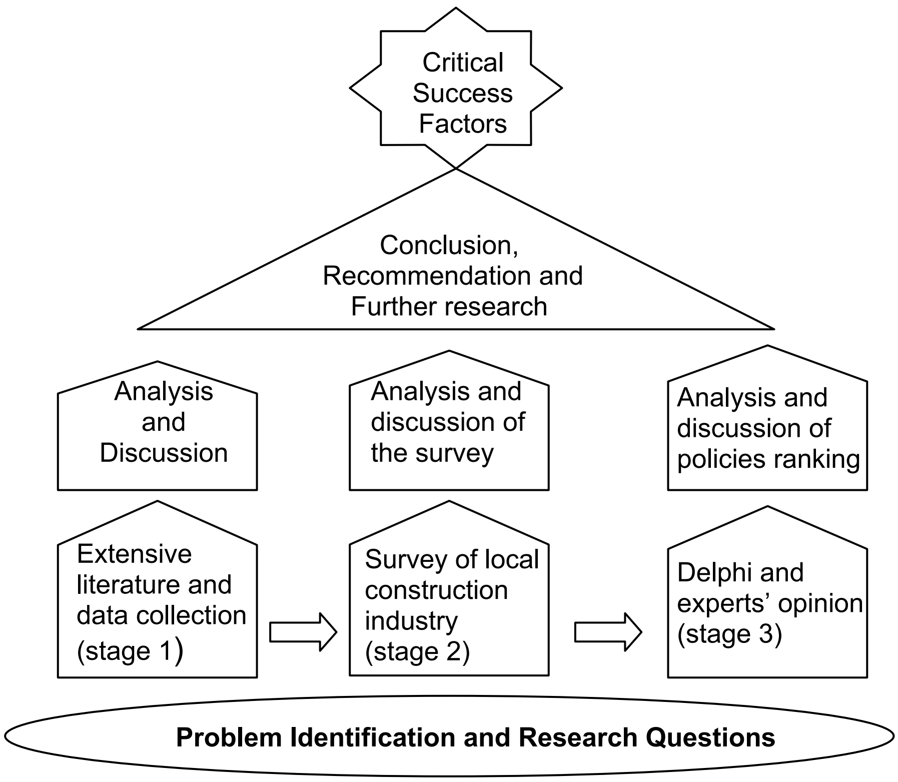


Figure 4.3 Research Procedure

4.5.1 Stage 1: Review Literature

The aim of the literature review is to examine previous research and identify the gaps in current knowledge. This review determined the context of the research study and positioned this work relative to previous research. It also assisted in the conceptualisation of the research areas sufficiently to develop the main focus of the research, influence the research design and generate specific hypotheses to be tested.

The activities included in this stage are:

- To develop a clear understanding of the research study
- Identify and describe the problem being studied
- To consolidate and extract information from a preliminary literature review for the main areas of investigation including critical delay factors, critical success factors, building construction, construction in developing countries and policies
- Formulate the study questions based on the problems identified and create a description of the research questions and objectives. The sources of information for collection of data for this activity include journal publications, books, magazine articles, international agendas and reports.
- Develop the methodology for the research.

4.5.2 Stage 2: Data Collection and Survey

The second stage of the research will investigate the delay factors in Brunei's building construction projects. It will also investigate the correlation of the delay factors with the critical success factors found in the literature. This includes the assessment from the knowledge gained from an extensive literature review and the data collection from the survey.

Stage 2 includes the following activities:

- Further investigation of literature relevant to the research.
- Collection of data.
- Identification of delay factors.

- Piloting: conduct a pilot survey in the early stages of the study in order to verify the quality and effectiveness of the questionnaire for both specific and general surveys. These pilot surveys intend to get feedback that could help the researcher improve the data collection strategy and also measure the exact time required to complete all questions, or identify any other problematic issues with the survey's format. The feedback received from the pilot survey is used to improve the final product.
- Sampling - random sampling is the purest form of probability sampling. Each member of the population has an equal chance of being selected. Random sampling was undertaken to select the participants (owners, contractors and engineers) for this survey.
- Conduct the specific survey. A targeted survey was designed to obtain the recollections of field experiences from the engineers. The target population for this survey are owners, contractors and consultants. These projects must have been nearly completed, or completed within the last 7 years.
- Analyse the survey result using reflective index and Spearman's rank correlation.
- Identify critical delay factors.
- Conduct the general survey. A general survey was created to gather opinions from experienced project managers and project teams who worked or were still working in the Brunei building construction field for at least the past ten years. The general survey will examine the correlation between the critical success factors and critical delay factors. The target population are owners, contractors and consultants.
- Analyse the results using the Pearson Correlation Coefficient, independent t-test, one way ANOVA and two-way ANOVA.
- Identify the critical success factors according to their priority.

4.5.3 Stage 3: Ranking and Validating

The activities for stage 3 include the following:

- Design the Delphi questionnaires and prepare associated letters for selected Delphi panellists (A sample letter is shown in Appendix G)
- Pilot the questionnaire with experienced project managers for their evaluation.
- Select the expert panel. Experts are qualified by their knowledge, skill, experience, training or education.
- Conduct the first round of the Delphi survey. First round questionnaires will be distributed to selected panels.
- Analyse the first round of the Delphi results. This questionnaire is used as the survey instrument for the second round of the data collection.
- Conduct the second round of the Delphi survey. In the second round, each expert panel receives a second questionnaire and is asked to review the items summarized from the research based on the information provided in the first round.
- Distribute another round of Delphi questionnaires if required, and continue to do so until the desired result is achieved.
- List and discuss the results of the rankings.
- Discuss the conclusions and suggestions for further research.

As a result of the following three steps:

- the results of the extensive review of the literature in stage 1
- collection of data from stage 2
- specific surveys on critical delay factors and general surveys on the correlation of delay factors and critical success factors

Lists of success factors will be proposed for improvement of building construction projects. An iterative group consensus using the Delphi method was developed to establish the priorities of these selected factors according to experts' opinions. The ranking of the critical success factors result from consensus responses among the panel of experts. The Delphi method, using the two-round approach, was used for this research study because it allows validation of the importance of the critical success factors which are necessary to improve project performance in building construction projects.

The Delphi questionnaire was initially discussed and piloted with experienced project managers, publicly and privately, and a number of qualified engineers. The piloting was done to test whether the questionnaire was intelligible, unambiguous and easy for the selected panel to understand and answer.

A panel of experts was identified to contribute to the research through the Delphi process. The personal character and professional experience of the panel and the relationship between the panels' background, topic to be investigated, the concepts identified, and the site of the study are important considerations, particularly for the Delphi questionnaire. The expert panel are representatives of government, business, educators, private construction firms, and local organizations. This was done to assure validity of the results based on reasonable distribution of expert opinion and expert judgement of the industry.

This expert panel comprised representatives of the Brunei government:

- The Permanent Secretary, the Ministry of Development and the Ministry of Finance
- Assistant Permanent Secretary, the Ministry of Development
- Director General of Public Works Department.
- Heads of sections of the Public Works Department.
- Experienced consultants.

The first questionnaire was forwarded to each member of the selected panel to solicit responses on the topics under consideration. This questionnaire is used as the survey instrument for the second round of data collection. The responses were summarised and provided to the panel in a second questionnaire. For the second questionnaire, each Delphi expert panel member is asked to review the items summarized by the researcher based on the information provided in the first round. This process was repeated as often as necessary to achieve a desired consensus. The number of Delphi iterations depends largely on the degree of consensus sought by the researcher and can vary from three to five. (Delbecq et al, 1975; Ludwig, 1994). When responses stabilised (that is, when the average ranking and the ranking order of each policy stabilised), the final round results were used as the consensus.

CHAPTER 5

DATA COLLECTION, ANALYSIS TECHNIQUES AND STATISTICS: STAGE 2 CRITICAL DELAY FACTORS

The objective of this research is to identify the causes of delay in the building construction industry and to assess the relative importance of these causes from the viewpoint of the owner, contractor and engineer. The current level of project success in the Brunei construction industry is very poor. This research investigates ten building construction projects that encountered delays in Brunei in order to understand the reasons for these failures, and to make recommendations that will help Brunei achieve its vision for development of its construction sector in the future.

A survey was conducted to assess the relative importance of causes of delays. A questionnaire was developed based on 28 well recognised causes of delay identified by Odeh and Bettaineh (2002). Participants were asked to indicate their level of importance of each cause. These causes were categorized into 8 major groups: client, contractor, consultant, material, labour and equipment, contract, contract relationship and external related factors.

Client related factors include causes of delay related to finance and payments for completed work, owner interference, slow decision making and unrealistic contract duration imposed by owners. Contractor related factors include delays caused by subcontractors, site management, inadequate construction methods, inadequate planning and errors during construction, and inadequate contractor experience. Consultant related factors include any cause of delay related to contract management, preparation and approval of drawings, quality assurance and waiting time for approval of test and inspection.

Material related factors include quality of material and shortage in material. Labour and equipment causes of delay include problems involving labour supply, labour productivity and equipment availability and failure. Contract related factors include delays as a result of change orders and mistakes or discrepancies in the contract. Contract-relationship related factors include problems involving major disputes and negotiations, inappropriate overall organizational structure linking to the project and lack of communication between the parties. External factors deal with the causes of delay due to weather conditions, regulatory changes, problems with neighbours and unforeseen site conditions.

5.1 RESEARCH QUESTION ONE

"What are the real causes of project delays in the Brunei building construction industry?"

A survey questionnaire was designed to obtain project parties' recollections of their field experiences. The target population for this survey were owners, contractors and engineers who were involved in Brunei's public building projects. The respondents were required to be members of project teams in order to get necessary technical data. The projects selected for this survey were projects that were nearly completed or completed within the last ten years. Project files for the selected projects were used by respondents as a reference to remember what happened on projects after 10 years. A questionnaire was developed to assess the perceptions of the owners, contractors and engineers on the relative importance of causes of delay in the Brunei building construction industry. (Details of the questionnaire can be found in Appendix G).

The survey questionnaire consisted of six parts:

Part One

Part one collects information to evaluate the validity of the project for this study. This part of the survey gathered information on demographics such as the project location, planned cost, type, actual cost, actual duration, planned duration, contract type, and project designer.

Part Two

Part two of the survey sought information about the owners' background and demographics. For the purpose of conducting a follow-up if required, participants were also asked to voluntarily provide contact information. To facilitate collection of any missing data, the researcher made it clear that the participants had to be representative of the owner who was involved with the project as this was the main basis for the research survey questionnaire. The types of questions asked in part two of the survey included: name of the project owners (in most cases these were agencies); type of organisation; owner's previous experience and on which types of projects this experience was gained; and availability of funding when the construction phase started.

Part Three

Part three of the survey questionnaire is information about the contractors. These include demographic questions about the contractors, name of the contractor, city and company category. The category identifies which contractors are eligible to bid for which construction projects. The categories are as follows:

Category 1 – less than B$ 25,000 (Aus $20,000)

Category 2 – B$25,000.00 (Aus $20,000) – B$250,000.00 (Aus $200,000)

Category 3 – B$150,000.00 (Aus $125,000) – B$500,000.00 (Aus $415,000)

Category 4 – B$500,000.00 (Aus $415,000) – B$1.5 Million (Aus $1.25)

Category 5 – B$1.5 Million (Aus $1.25 M) – B$5.0 Million (Aus $4.2M)

Category 6 – B$5 Million above (Aus $4.2 Million)

Part Four

Part four sought information about the engineers, including demographic questions about the engineer, academic qualifications, length of experience and job classification.

Part Five

Part five of the survey focused on causes of construction delay. The respondents were asked to indicate their responses to categories established from 28 well-recognized construction delay causes as identified by Odeh and Battaineh (2002). A pilot study on the survey among the owners, engineers and contractors confirmed that they agreed on the causes of delays as identified, and no modification to this list was required. These causes were categorised into the following eight major groups:

1. Client related factors: delays caused by financial issues and payment for completed work, owner interference, slow decision making and unrealistic contract duration imposed by owners.
2. Contractor related factors: delays caused by subcontractor, site management, inadequate construction methods, inadequate planning and errors during construction, and inadequate contractor experience.
3. Consultant related factors: delays caused by contract management, preparation and approval of drawings, quality assurance and waiting time for approval of test and inspection.
4. Material related factors: delays caused by the quality of material and shortage of material.
5. Labour and equipment related factors: delays caused by labour supply, labour productivity and equipment availability and failure.
6. Contract related factors: delays caused by change orders and mistakes or discrepancies in the contract.
7. Contract relationship related factors: delays caused by major disputes and negotiations, inappropriate organisational structure linking to the project and lack of communication between the parties.
8. External factors: delays caused by weather conditions, regulatory changes, problems with neighbours and unforeseen site conditions.

Part Six

Part six of the survey allowed respondents to identify additional causes of delay in addition to the twenty eight delay factors listed above.

5.2 SAMPLING AND TARGET POPULATION

Sampling

The survey used random sampling as it is the purest form of probability sampling. Each member of the population had an equal chance of being selected, provided the project's specific constraints were met. The sample selected comprised those with at least five years' experience in the Brunei construction field.

1. Owners

The owners are the future occupiers of buildings who are involved during the construction stage of the project. The owners were selected from the list of buildings completed.

2. Contractors

These are lists of contractors classified in building construction according to government classification systems identified from the registered list published by Brunei's Ministry of Development. Contractors are categorised according to categories 1 – 6. (Category descriptions explained above)

3. Engineers

The engineer is defined as a project manager or designer who interprets the owner's needs and creates a tangible blueprint of the project. The engineers are responsible for project design. They finalise the project, determine which materials will be used and how they will fit together, and develop the project's drawings and specifications.

Targeted Population

The specific project survey targeted building and utility projects in Brunei that had been completed or partially completed within the past 10 years. The delay factors were limited to delays between 6 and 18 months. The projects surveyed consisted of building projects with the following break-down: residential, office, hotel, academic buildings and mosques. The projects' contract prices ranged from B$500,000.00 (Aus $415,000) to B$100 million (Aus $83 million), while the building heights ranged from 6 - 20 storeys.

Three of the projects surveyed used the services of consultants, that is, an engineer employed on behalf of public works. Seven of the projects surveyed were managed by engineers from the public works department. All the projects used main contractors and also nominated subcontractors, and the contract used for all the projects is the traditional contract.

5.3 SURVEY PROCEDURE

Pilot Survey

A pilot survey was conducted using ten owners, ten contractors and ten engineers to rank the list of causes of delay factors identified by Odeh and Bettaineh (2002). The basic purpose of the pilot survey was to verify the completeness of the survey questionnaire in capturing the factors relevant to the research in Brunei. All the respondents agreed that the questionnaire was sufficient to capture the causes of delays. Therefore no modification was made to the causes of delays identified by Odeh and Battaineh (2002).

Participation Arrangements

The participants were informed in advance with proposed target organisations (project owners, contractors and consultants) in order to clearly identify the sample population.

Time Scale

Each respondent was initially given three weeks to complete the survey, and then a reminder was sent allowing an additional three weeks for completion.

Receiving Data

For the internet based survey, the data was downloaded from the survey database. For hard copy survey collection, a colleague of the researcher acted as an intermediary, receiving all the completed surveys and arranging for them to be mailed to Brisbane.

Study Limitations

Although attempts were made to interview all parties involved with projects, some parties could not be reached. However parties that could be reached on site were most willing to cooperate. Construction managers and major contractors on the ten sites were adequately covered. As the survey was conducted on building projects located in Bandar Seri Begawan (the capital city of Brunei), it would seem inappropriate to generalise for the whole of Brunei on the basis of this data. However, a large proportion of the high-rise building construction works in Brunei are located in the city area. It is recommended that further research is undertaken to determine the extent to which the results can be extrapolated to other parts of Brunei and to other countries.

5.4 STATISTICAL METHOD

5.4.1 Relative Importance Index

The Relative Importance Index (RII) is a statistical method to determine the ranking of different causes. As this survey was designed to determine the relative importance of various causes of delays, the method was adopted in this study within various groups (i.e. owners, contractors or engineers). The RII five-point scale, ranging from 1 (not important) to 5 (extremely important) was adopted and transformed the relative importance indices (RII) for each factor as follows:

$$RII = \frac{\sum W}{A * N}$$

where W is the weighting given to each factor by the respondents (ranging from 1 to 5), A is the highest weight (i.e. 5 in this case), and N is the total number of respondents. The RII value had a range from 0 to 1 (0 not inclusive). The higher the value of RII, the more important was the cause or effect of delays.

The RII was used to rank the relative importance index of the different causes. These rankings made it possible to cross-compare the relative importance of the factors as perceived by the three groups of respondents (i.e. owners, contractors and engineers). Each individual cause's RII, as perceived by all respondents, was used to assess the general and an overall ranking in order to give an overall picture of the causes of construction delays in Brunei's building construction industry.

5.4.2 Spearman's Rank Correlation

Spearman's rank correlation is a non parametric test. It is used when you have two measurement variables and one "hidden" nominal variable. It is also used when one or both of the variables consist of ranks. These tests have the obvious advantage of not requiring the assumption of normality or the assumption of homogeneity of variance. They compare medians rather than means and, as a result, if the data has one or two outliers, their influence is negated. Spearman's rank correlation is a technique used to test the direction and strength of the relationship between two variables. In other words, it is a device to show whether any one set of numbers has an effect on another set of numbers. It uses the statistics R_s which falls between -1 and +1.

As Spearman's rank correlation is a technique to test the direction and strength of the relationship between two variables, the method was adopted in this research to show the degree of agreement between the different parties. The correlation coefficient varies between +1 and -1 with +1 implying a perfect positive relationship (agreement) and -1 implying a perfect negative relationship (disagreement). It might be said then that sample estimates of correlation close to unity in magnitude imply good correlation, while values near zero indicate little or no correlation. The Spearman's rank correlation coefficient r is used to measure and compare the associations between the rankings of two parties for a single cause of delay, while ignoring the ranking of the third party. It is calculated using the following formula:

$$r's = 1 – [(6 \sum d^2)/(n^3 - n)]$$

Where r is the Spearman's rank correlation coefficient between two parties, d is the difference between ranks assigned to variables for each cause, and n is the number of pairs of rank. The null hypothesis is that the ranks of one variable do not relate to the ranks of the other variable. In other words, as the ranks of one variable increases, the ranks of the other variable are not more likely to increase (or decrease).

Spearman's rank correlation works by converting each variable to ranks. Once the two variables are converted to ranks, a correlation analysis is done on the ranks. The correlation coefficient is calculated for the two columns of ranks, and the significance of this is tested in the same way as the correlation coefficient for a regular correlation. (The Spearman's correlation coefficient is also called Spearman's rho). The P-value from the correlation of ranks is the P-value of the Spearman rank correlation. The procedures for using Spearman's Rank Correlation are:

1. State the null hypothesis i.e. "There is no relationship between the two sets of data."
2. Rank both sets of data from the highest to the lowest. Make sure to check for tied ranks.
3. Subtract the two sets of ranks to get the difference d.
4. Square the values of d.
5. Add the squared values of d to get sums of d2.
6. Use the formula Rs = 1 – (6 Sums d/n – n) where n is the number of ranks you have.
7. Between two sets of data, if the Rs value

…is -1, there is a perfect negative correlation.

…falls between -1 and -0.5, there is strong negative correlation.

…falls between -0.5 and 0, there is a weak negative correlation.

….is 0, there is no correlation.

…falls between 0 and 0.5, there is a weak positive correlation.

…falls between 0.5 and 1, there is a strong positive correlation

…is 1, there is a perfect positive correlation.

8. If the Rs value is 0, state that null hypothesis is accepted. Otherwise, say it is rejected.

5.5 ANALYSIS PROCEDURE

The statistical analysis procedures that were used for each part of the survey questionnaire are as follows:

- Part 1 (project information): Frequencies and percentages are used to summarise responses.
- Part 2 (owner information): Frequencies and percentages are used to summarise responses to questions about type of organisation, owner experience, and availability of funding. It also shows owners' ranking of the causes of the delay factors.
- Part 3 (contractor information): Frequencies and percentages are used to summarise responses to questions about contractor category, experience and financial background. It also shows contractors' ranking of the causes of the delay factors.
- Part 4 (Engineer Information): Frequencies and percentages are used to summarise responses to questions about engineers' background and experience. It also shows engineers' ranking of the causes of the delay factors.
- Part 5 (Project factors evaluation): Relative Importance Index is used to rank delay factors by respondent (owner, engineer and contractor) and the Spearman correlation to test agreement between respondents (owner, contractor and engineer).
- Part 6 (Additional Causes of Delay factors): Participants to add any causes of delays that they think should be considered.

5.6. RESEARCH FINDINGS AND RESULTS

General characteristic of respondents

Respondents included 30 owners, 25 contractors and 20 engineers out of 35, 35 and 35 distributed questionnaires respectively. Respondents have an average experience of between 10 and 20 years, and have handled projects that cost between B$500,000.00 (Aus $415,000) to B$100 Million (Aus $83 Million). The contractors surveyed are categorised as class 4, 5 and 6 (categories explained previously).

5.7. ANALYSIS OF DATA

The demographic characteristics of the respondents are given in Table 5.1.

Table 5.1 Demographic Characteristics of the respondents

Demographic characteristics	Frequency	Percent
Age		
Less than 20	Nil	Nil
30 – 39	22	29.33
40 – 49	35	46.70
50 and above	13	17.33
Sex		
Male	53	70.67
Female	22	29.33
Education		
Lower secondary (Form 1-3)	Nil	Nil
Upper secondary (Form 14-5)	Nil	Nil
Pre-University(Form 6)	5	0.07
University	40	53.33
Post Graduate	30	40.00
Type of Organization		
Clients (government or developer)	30	40.00
Consultant	20	26.70
Contractor	25	33.30
Occupational level		
Non-executive	15	20.00
Executive	38	50.67
Managerial	22	29.33
Numbers of years working experience		
Less than 2 years	Nil	Nil
2 – 5 years	Nil	Nil
6 – 10 years	26	34.67
More than 10 years	49	65.33
Field of specialization		
Building	36	48
Infrastructure	18	24
Mechanical and Electrical	16	21.33
Others	5	6.67
Largest project involve based on contract sum		
Less than 10 millions	Nil	
10 millions – 50 millions	8	
More than 50 millions	2	

5.7.1 *Results of Analysis*

The data was analysed from the perspective of owners, contractors and engineers. Each individual cause's RII perceived by all respondents was computed for overall analysis. From the ranking assigned to each cause of delay, the most important factors or causes of delays in Brunei's building construction industry were able to be identified. Table 5.2 gives the ranking of causes based on the responses of all respondents (owners, contractors and engineers). Table 5.3 summarizes RII and ranking of the categories of delays as perceived by respondents.

Table 5.2 Ranking Causes of Delays (based on overall participant)

Causes of delays	**Importance of delay**					**Overall**
Client related causes	1	2	3	4	5	R11
Finance and payments of completed work		5	18	32	20	0.7787
Owner interference	1	10	25	32	7	0.6907
Slow decision making	1	2	15	33	24	0.8053
Unrealistic contract duration and requirements imposed	1	11	33	23	8	0.6773
Contractor related causes						
Subcontractor performance		5	21	28	21	0.7733
Site management	2	5	14	40	14	0.7573
Construction methods	1	8	18	31	17	0.7467
Inadequate planning	2	3	18	29	23	0.7813
Mistakes during construction stage	1	8	28	27	11	0.7040
Inadequate contractor experience		5	22	32	16	0.7573
Engineer/consultant related causes						
Contract management		11	34	23	7	0.6693
Preparation and approval of drawings		12	22	31	10	0.7040
Quality assurance/control	2	15	25	23	10	0.6640
Waiting time for approval of tests and inspection	1	10	28	29	7	0.6827
Material related causes						
Quality of material	3	8	31	24	6	0.6347

Shortage in material	1	7	20	28	19	0.7520
Labour and equipment category causes						
Labour supply	2	5	23	31	14	0.7333
Labour productivity	2	7	30	28	8	0.6880
Equipment availability and failure		7	22	35	11	0.7333
Contract related causes						
Change orders		5	19	28	23	0.7840
Mistakes and discrepancies in contract document		6	23	29	17	0.7520
Contract relationships related causes						
Major disputes and negotiations		11	36	22	6	0.6880
Inappropriate overall organizational structures linking to the project		5	36	23	11	0.7067
Lack of communication between the parties	1	3	11	34	26	0.8160
External causes						
Weather conditions	1	15	26	29	4	0.6533
Regulatory changes	1	13	26	23	12	0.6853
Problem with neighbours	3	16	33	20	3	0.6106
Unforeseen site conditions	2	7	24	31	10	0.6987

*R11: Reflective index

Table 5.3 Ranking Categories of Causes of Delay

Causes of Delay	Owner	Rank	Engineer	Rank	Contractor	Rank	Overall	Rank
Client related	0.678	5	0.758	3	0.794	1	0.738	3
Contractor related	0.746	1	0.777	1	0.759	5	0.753	2
Engineer/ Consultant related	0.648	7	0.683	7	0.728	4	0.680	7
Material related	0.673	6	0.730	5	0.760	3	0.693	6
Labour and equip related	0.7	4	0.717	6	0.717	8	0.718	5
Contract related	0.7	3	0.765	2	0.772	2	0.768	1
Contract relationship related	0.731	2	0.757	4	0.725	6	0.737	4
External causes	0.622	8	0.675	8	0.718	7	0.662	8

In order to test the degree of agreement between the three groups of respondents, a correlation analysis using Spearmen's rank correlation coefficient was done. This test showed the relationship between owners, contractors and engineers on their agreement about the delay factors. Table 5.5 shows the correlation between the respondents. Owners, contractors and engineers show a positive correlation on their agreement on the delay factors. High correlation indicates that there is a high degree of agreement between the respondents.

Table 5.4 Spearman Correlation (owner, contractor and engineer)

Correlations

			OwnerRnk	ContRnk	EngRnk
Spearman's rho	OwnerRnk	Correlation Coefficient	1.000	.272	.382*
		Sig. (2-tailed)	.	.161	.045
		N	28	28	28
	ContRnk	Correlation Coefficient	.272	1.000	.372
		Sig. (2-tailed)	.161	.	.051
		N	28	28	28
	EngRnk	Correlation Coefficient	.382*	.372	1.000
		Sig. (2-tailed)	.045	.051	.
		N	28	28	28

*. Correlation is significant at the 0.05 level (2-tailed).

5.7.2 Discussion of results

This section discusses the results obtained from the surveys on the causes of delay factors. Results shown in table 5.2 indicate that the seven most important causes of delay were identified as:

(1) Lack of communication

(2) Slow decision making

(3) Change orders

(4) Inadequate planning by the contractor

(5) Finance and payment of completed work

(6) Subcontractor performance

(7) Inadequate contractor experience

The inadequate contractor experience has exactly the same R11 value (0.7573) as site management. Inadequate contractor experience was selected based on the number of participant highest score of “5” on importance of delay. The delay factors were categorised into 8 groups for evaluation on the group causes of delays. Based on the ranking of the group categories of causes of delay shown in Table 5.3, the following is a brief consideration on the causes of delay based on follow up discussions and information from owners, contractors and engineers after the survey.

Owners’ factors causing delay in construction projects

The owner-related group of delay factors was most important to contractors and engineers. This is mainly due to financing issues and owner interference, which are considered very important by both parties. It is interesting to note that slow decision-making by owners and unrealistic contract duration are more important to engineers than to contractors. This is because contractors rank operational issues, such as labour productivity and equipment availability and failure, more highly. Unlike contactors, however, engineers consider the owner-related factors to be more important than operational ones. Overall, slow decision making is the major owner-related factor affecting delay in construction projects in Brunei.

Contractors’ factors causing delay in construction projects

Both owners and engineers ranked this group of causes highly. It is worth noting that engineers are mainly concerned with technical factors such as inadequate contractors’ experience, delays caused by subcontractor performance, and inadequate planning, while contractors are concerned about the delay factors caused by subcontractor performance.

Inadequate contractor planning was the most important factor in this group. This can be attributed to the contract awarding procedure in Brunei, where most projects are awarded to the lowest bidder. Moreover, local contractors, solely or through joint ventures, are being awarded large and complex projects for which they have little experience, because access to such projects was generally limited to international contractors in the past. Delays caused by subcontractor performance are also of high importance to engineers. This can be attributed to inadequate subcontractor experience, the bid-shopping practice of general contractors, and inadequate planning and coordination.

Inadequate planning is also troublesome to contractors and engineers. Local contractors are reluctant to use scheduling techniques and to update schedules on a regular basis. Despite the fact that contractors are required to provide work schedules on most projects, these are often ‘summary’ schedules that are rarely updated during construction. Delays caused by inadequate construction methods are more important to engineers. Fluctuation in the construction market and the seasonal nature of the industry has forced many contractors to diversify. As a result, they do not focus on one line of work, but try to adopt advanced methods and techniques.

Site management is another important cause of delay to contractors. This is due to the reluctance of contractors to invest in planning and control and to the lack of professional construction managers. The majority of site managers are civil engineers with good work experience but little training or education in management. Overall, inadequate planning by the contractor is a major cause of delay.

Engineers’/Consultants’ factors causing construction delays

Neither owners nor engineers ranked this group of factors high among the major groups of delay-causing factors. Contrary to expectations, engineers consistently ranked each of these causes higher than contractors. The highest ranked factor among these causes was contract management. This could be attributed to the lack of authority the owners are willing to delegate to engineers to enable them to manage the contract effectively. This finding is consistent with the high ranking of owner interference and the low ranking of factors over which the owners are usually granted authority. These latter factors include preparation and approval of drawings, quality assurance/control, and approval of tests and inspections. Preparation and approval of drawings by engineers is the most significant delay factor for this group rated by contractors.

Materials' factors causing delay in construction projects

The group of materials-related causes received high rankings from engineers. The quality of material was among the least important causes because most of the available material - especially cement, steel and asphalt - is locally provided with little variation in quality. Shortages of material received a higher ranking than quality. This is particularly true for imported material that may take a considerable time to procure. The shortages of materials can also result from an absence of adequate statistics on material availability, fluctuations in the availability of construction materials, very long average waiting times and uncertainty about the deliveries of ordered materials and shortages of funds to procure materials, and inadequacy in terms of transportation.

Labour and equipment factors causing delay in construction projects

This group of causes was ranked high by contractors and engineers. As expected, this group is more important to contractors than engineers. This was true for labour productivity and for equipment availability and failure. While labour supply is not that important considering the relatively inexpensive supply of foreign and local labourers, the productivity of the labour force was the top ranked factor. This may be attributed to lack of incentives for higher productivity, lack of or inadequate training, and the absence of trade unions or associations that regulate, train, and classify construction trades. Equipment availability is the most important factor in this group that causes delays in the construction projects.

Contract related factors causing delay in construction projects

This group of causes had greater variation in ranking than any other group. While it was considered important by contractors, it was less important for engineers. Engineers - who are usually empowered to issue changed orders and to correct mistakes and discrepancies in contract documents - are less critical of their role in causing such delays, in contrast to contractors.

Contractors believe the poor contract management produces deficiencies in the contractor's plan, cost control and overall site management.

Contractual relationship factors causing delays in construction projects

This group of causes was ranked high by owners, contractors and engineers. Factors relating to organisation and communication were more important to engineers than to contractors. Delays caused by disputes and negotiations were less important to all respondents, especially for public projects where arbitration is not allowed and where legal recourse through courts takes a considerable time. The respondents (contractors, engineers and owners) strongly agree that a lack of communication between project teams is the most important of the delay factors that cause delays in the construction projects.

External factors

External factors were the lowest ranked group of factors by both parties. It seems that all parties are familiar with these factors and are able to deal with them effectively, thus avoiding major delays.

5.8 CONCLUSION

The results of the survey questionnaire from the stakeholders (owners, contractors and engineers), are summarised in Table 5.5, which lists the rankings by owners, contractors, engineers (and overall) of the most important delay factors. The seven most important causes of building construction delays as perceived by owners were:

(1) Lack of communication between parties
(2) Slow decision making
(3) Inadequate planning
(4) Change orders
(5) Inadequate contractor experience
(6) Labour supply
(7) Subcontractor performance

The seven most important causes perceived by contractors were:

(1) Slow decision making

(2) Finance and payment for completed work

(3) Subcontractor performance

(4) Shortage in materials

(5) Site management

(6) Mistakes and discrepancies in the contract

(7) Lack of communication

The seven most important causes perceived by engineers were:

(1) Lack of communication

(2) Slow decision making

(3) Change orders

(4) Contractor inadequate planning

(5) Finance and payment for completed work

(6) Subcontractors performance and

(7) Shortage in material.

Table 5.5 Summary Results of Critical Delay Factors

Owner	**Engineer**	**Contractor**	**Overall**
Lack of communication	Lack of communication	Owner slow decision making	Lack of communication
Slow decision making	Slow decision making	Finance and payment of completed work	Slow decision making
Inadequate contractor planning	Change orders	Subcontractor performance	Change orders
Change orders	Contractor inadequate planning	Shortage in material	Inadequate contractor planning
Inadequate contractor experience	Finance and payment of completed work	Site management	Finance and payment of completed work
Labour supply	Subcontractor performance	Mistakes and discrepancies in contract document	Subcontractor performance
Subcontractor performance	Shortage in material	Lack of communication	Inadequate contractor experience

There were three delay factors common to the groups of participants. These are “Lack of communication”, “Slow decision making” and “Subcontractor performance”. Other delay factors common between two groups are “Change Orders”, “Inadequate Contractor Planning”, and “Shortage of Material”.

The researcher identified the seven most important causes of delay based on the overall rankings by respondents. These are:

(1) Lack of communication between parties
(2) Slow decision making
(3) Change orders
(4) Inadequate contractor planning
(5) Finance and payment of completed work
(6) Subcontractor performance
(7) Inadequate contractor experience

The value of Spearman’s rank correlation coefficient shows that there is relatively good agreement between each of the groups in ranking the importance of the delay factors. The following discusses opinions of the respondents’ from the specific surveys about the delay factors identified in construction projects, and a follow-up discussion on the causes of the delay factors.

5.8.1 Lack of communication between parties

Since there are many parties involved in a project (owner, engineer, contractor, subcontractor), the communication between the parties is crucial to the success of the project. Proper communication channels between the various parties must be established during the planning stage. Problems with communication can lead to serious misunderstandings and therefore, delays in the execution of the project. There is no communication team overseeing all project team members throughout the life cycle of the project. The roles and responsibilities of team members were not clearly identified and the project teams were represented by different authorities or departments. There are no appropriate overall organisational structures and communication systems linking all project teams throughout the life of the project.

5.8.2 Slow decision making

The slow speed of decision making affects all project teams. The design document, including drawings and specifications, does not provide the contractor with a clearly defined basis to plan the resource needs of a construction project. The information flow between all project team members was neither timely nor well organised and the decision-makers were not clearly identified. There is no appropriate overall organisational structure.

Owners are accused of being slow in decision making, and in many instances contractors waste resources waiting for owners to decide on specialist contractors and designers, decorative material and suppliers, and provision of adequate information on changes required. Some of the change orders are large-magnitude changes requiring extensive redesign.

Most decisions are made by committees which are, by their nature, slow decision makers in comparison to individuals. Committee decisions tend to be compromises rather than optimal solutions to problems, and are delayed due to scheduling issues: committees have meetings scheduled in advance, so that decisions that affect project execution have to await the next meeting of the committee. This slow response inevitably delays work on site.

5.8.3 Change orders

There are frequent change orders requested by owners in response to requirements from their management. Owners need to minimise change orders during construction to avoid delays. Some change orders come from engineers seeking to save costs on additional works. Variations are the cause of many problems in building contracts and increase a project’s time and cost. Project teams were not clearly and thoroughly briefed by the client. The technical feasibility studies undertaken before project authorisation are inadequate. Owners’ requests for changes are usually made at short notice, thereby impacting on the contractor’s plan. Some change orders can be of a large magnitude, requiring extensive redesign. The owners rated design errors made by the engineers as the most important delay factor to change orders. Change orders are also linked to inadequate technical feasibility studies before project authorisation. This is further explained in most circumstances by projects being rushed to their commencement, and political committees overriding the detailed preparation of project plans. There are no comprehensive strategies formulated to minimise variations.

5.8.4 Inadequate contractor planning

Local contractors often fail to produce a practical and workable "work program" at the initial planning stage. This failure reflects the lack of systematic site management and inadequate contractor experience on Brunei's construction projects. Inadequate contractor planning results in lack of sufficient detail and an emphasis on decoration in some plans. Despite the fact that contractors are required to provide work schedules on most projects, the schedule is often a summary schedule that is rarely updated during construction. Poor contract management also leads to inadequate contractor planning which results in a very low level of productivity, inadequate finances for short and long term purposes, an absence of specialisation and inadequate technical power.

5.8.5 Owners' finance and payments for completed work

Construction projects in Brunei involve large amounts of money. Many contractors find it difficult to bear the daily construction expenses when their payments are delayed, resulting in an inadequate cash flow to support construction expenses, exacerbated for those contractors who are not financially sound. Irregular payment on public projects is a major cause of liquidity problems for contractors. The major financier of construction projects in Brunei is the Brunei Government (owner). This may be attributed to the dominant culture within the industry, since the government still bears the whole burden of project financing. At present there is no participation by private investors in financing public sector projects. There is also no participation by contractors in financing projects, and this could be due to the traditional contract method commonly in practice in building construction projects.

5.8.6 Subcontractor performance

In large construction projects there are typically many subcontractors working under the principal contractors. If the subcontractors are capable, the project can be completed on time. However, the project will be delayed if the subcontractor underperforms due to inadequate experience or capability. A high degree of subcontracting in Brunei leads to a high risk of delays, and this leads to inefficiencies in the entire construction industry, attributable to the inadequate experience of subcontractors, the bid-shopping practice of general contractors, and to inadequate planning and coordination.

5.8.7 Inadequate contractor experience

Inadequate contractor experience was an important factor affecting project delays. This can be linked to the contract-awarding procedure where most projects are awarded to the lowest bidder, and where local contractors, solely or through joint ventures, are awarded large and complex projects for which they have little experience because access to such projects was limited to international contractors in the past.

CHAPTER 6

DATA COLLECTION, ANALYSIS: CORRELATION OF DELAY FACTORS AND SUCCESS FACTORS

The seven most significant success factors identified by Ashley et al. (1987) have been adopted for this study due to the comprehensive, detailed nature of the descriptions and because much of the research undertaken since Ashley's study has been based on this work. The seven most significant success factors in determining project success, which have been chosen for further investigation in this study, are:

1. Organisational planning
2. Project manager goal commitment
3. Project team's motivation and goal orientation
4. Clarity of the project's scope and work definition
5. Project manager's capabilities and experience
6. Safety precautions and applied procedures
7. Use of control systems

The identified seven delay factors discussed in Chapter 5 of this thesis, and the top seven success factors noted above, are summarised in Table 6.1. These will be referred to as the critical delay factors and critical success factors. In addition to the seven critical success factors and seven delay factors (identified and justified in chapters 5 and 6), respondents were given the opportunity to add information about any other success or delay factors they may have experienced in the projects (in the questionnaire undertaken to correlate delay and success factors).

Table 6.1 Critical Success Factors and Critical Delay Factors

Success factors		Delay factors	
S1	Organisational planning	D1	Lack of communication among project parties
S2	Project manager's goal commitment	D2	Slow decision making
S3	Project team's motivation and goal orientation	D3	Change orders
S4	Clarity of the project's scope and work definition	D4	Inadequate contractor planning
S5	Project manager's capabilities and experience	D5	Finance and payment for completed work
S6	Safety precautions and applied procedures	D6	Subcontractors performance
S7	Use of control systems	D7	Inadequate contractor experience

6.1 SURVEY STRUCTURE

A general survey (Appendix H) was designed to survey owners, contractors and engineers who are involved in Brunei's public building construction projects. A questionnaire was developed to assess the perceptions of the owners, contractors and engineers on the relative importance of causes of delay in the Brunei building construction industry. The survey consisted of six parts:

Part One

Part one sought information from respondents on projects' actual delays, the extent of the delays, types of contract used, types of project, actual cost, actual duration, and project management. This information helped to evaluate the project validity for this research, as the research required participants who had experienced project delays.

Part Two

Part two of the survey collected information about the owner. The types of questions asked in part two of the survey include: name of the project owners (in most cases these were agencies); type of organisation; owner's job position, owner's time with the organisation and owner's previous experience and on which types of projects this experience was gained; and availability of funding when the construction phase started. Information about the respondents' knowledge, experience and contact details was also sought here. This part of the survey helped the researcher to clarify an owner's experience with projects and project teams during construction.

Part Three

Part three of the survey includes demographic questions about the contractors. These include the name of the contractor, category of the contractor, type of company (for example building contractor, structural contractor, mechanical & electrical contractor, etc), local or international contractor, experience working internationally, company partnership details, and financial background of the contractor. The contractor was also asked to list all types of contract they have experienced in the building construction industry. This part of the survey helped to clarify contractor involvement in the building construction industry locally and internationally, which helped the researcher to validate the outcome of the survey.

Part Four

Part four sought information about the engineers or designers. This included demographic questions about the engineer, years of experience, academic qualifications and job classification. This part of the survey also asked the engineers about the type of projects they have experienced, the minimum and maximum costs of projects they have handled, approximate number of projects they handle each year, and their experience as a project manager. This information will help the researcher to validate the outcome of the survey, as the research requires participation by engineers with at least five years' experience in building construction projects.

Part Five

In this section, the owners, contractors and engineers were asked to evaluate construction project success and delay factors in general. The evaluation scale was a five-point scale (very good = 5, good = 4, fair = 3, poor = 2, very poor = 1). At the end of each question, respondents were given the opportunity to add information about any other success or delay factors they may have experienced on the projects. Very few participants added anything new in response to this question, but the answers provided general knowledge about how success and delay factors were perceived in construction projects in Brunei.

Part Six

The relationships between success and delay factors were assessed through the respondents' answers to seven questions. Each question ascertained the presence of each of the delay factors, and the degree to which the project suffered due to these delay factors. If a respondent answered in the positive, they were asked to provide information about the influence of the top seven success factors as well as the noted delay factor. The evaluation scale for this question was also a five-point scale (completely = 5, a good deal = 4, a moderate amount = 3, a small amount = 2, and not at all = 1). For example, one of the questions asked to what extent an owner's cash flow problems during construction could have been avoided and/or prevented by a success factor (e.g. organisational planning). Respondents were also given the opportunity to identify any other success factors that could be used to avoid or prevent the noted delay factor.

Part Seven

Part 7 of the survey gave respondents the opportunity to identify additional causes of delay and success, beyond the top seven already identified. Respondents were asked to evaluate these factors with the same 5-point scale. No survey participants provided a response that indicated any new delay factors, means of avoiding delay, or any new success factors that could avoid delay factors.

6.2 STATISTICAL METHOD

As discussed in the methodology section in chapter 4, analysis was undertaken for each category of data collected, using statistical analysis software (SPSS). The following statistical instruments were used in this study:

6.2.1 Pearson Correlation Coefficient

A Pearson correlation coefficient measures the strength and directions of the relationship between two quantitative variables. It ranges from -1 (perfect negative correlation) to +1 (perfect positive correlation). It is calculated by dividing the covariance of the variables by the square root of the product of their variance. Correlation is a measure of how two random variables X and Y "move" with respect to each other. Pearson's r is computed by:

$$\mathbf{r = \frac{(x - \bar{x})^2 \times (y - \bar{y})^2}{\sum \overline{(x-\bar{x})^2 \times (y - \bar{y})^2}}}$$

In this study r was used to measure the strength and direction of the relationship between ratings of critical success and delay factors. This method was used specifically to evaluate responses in part of the general survey.

Hypothesis testing: Pearson's correlation r is a sample statistic. To test if X and Y are significantly correlated in the population, we test the hypothesis that the population correlation coefficient, rho (ρ) is significantly different from 0.

The test statistic is given by: $T_{test} = r(\surd n-2)/(\surd 1-r^2)$

The critical value is t for a chosen significance level (a = 0.05) and (n -2) degrees of freedom. The null hypothesis is rejected if $t_{test} > t_{critical}$

6.2.2 Independent t test

The independent sample t test was used to compare the population means based on sample statistics from two independent populations. In this study a t test was used to compare the perceptions of owners, contractors and engineers, about the influence of individual success factors on individual delay factors for specific projects.

Assumptions:

1) The dependent variable is normally distributed.

This assumption was not formally tested since the statistical literature has shown that the consequences of breaking this assumption are not serious, as long as sample sizes are not extremely small.

2) The two groups have approximately equal variance on the dependent variable.

The statistical software used to conduct analyses, SPSS, provides a test of this assumption and also provides results from a form of the t-test that does not assume equal variances in case there is evidence that the assumption is not met.

3) The two groups are independent of one another.

For this research study, the following generic non-directional hypotheses (two tailed) has been tested at a level of significance of a = 0.05.

$$H0: \mu 1=\mu 2$$

$$H\imath: \mu 1 \neq \mu 2$$

Significance in this test is evaluated based on the p-value. A small p-value signifies that the test is significant and that a conclusion can be drawn from the results. For example if the p-value is greater than 0.05, the test is insignificant and no conclusions can be drawn.

6.2.3 One Way ANOVA

One-way ANOVA is the statistical methodology for comparing means of several populations. It is called analysis of variance, or simply ANOVA. ANOVA is a generalised test for the comparison of the means, where the z and t tests can be used to compare, at most, two groups. In this study to compare the mean ratings of the influence of the seven success factors on each of the delay factors in order to learn which success factors demonstrated the most influence, a one-way ANOVA has been used. Table 6.2 show equations for one-way ANOVA.

Table 6.2 One Way ANOVA Equations

Source	Equation	F (test)
Mean square treatment	$\frac{n_1(\bar{y}_1-)^2+n_2(\bar{y}_2-\bar{y})^2+\ldots+n_k(\bar{y}_k-\bar{y})^2}{K-1}$	$F = \frac{MSTr}{MSE}$
Mean square error	$\frac{(n_1-1)S_1^2+(n_2-)S_1^2+\ldots.+(n_k-1)S_k^2}{N-K}$	
	Where N = total numbers of observations, K = number of groups n1 = sample size in each group, ☐ı = mean of group i y = overall mean, S_1^2 = variance of group I	

A separate analysis was carried out for owners, contractors and engineers. The repeated measures form of ANOVA was used in this context because the same participant rated all seven of the success factors. In the between-subjects or independent groups' form of ANOVA, it is assumed that groups are independent, whereas in the repeated measures form a correlation between multiple measures of the same participants is assumed.

In ANOVA, we test the alternative hypothesis (H1) that at least one of the group means is different from the others, and compare this with the null hypothesis (H0) that there is no difference between the means.

H0: $\mu 1=\mu 2=\mu 3=\ldots=\mu is$ H1: not all the are μs equal.

Assumptions of a one way repeated measures ANOVA:

- Dependent variable is normally distributed
- Independence of observations between subjects
- Homogeneity of variance across measures
- Homogeneity of covariance between pairs of measures.

6.2.4 Two Way ANOVA

The two-way analysis of variance is an extension of the one-way analysis of variance. There are two independent variables, both of which are categorical. In this study the two-way ANOVA has been used for two purposes:

1. To compare the perceptions of owners and contractors, owners and engineers, and engineers and contractors regarding the relative influence of the seven success factors on each delay factor.
2. To compare the perceptions of owners, contractors, and engineers.

The form of two-way ANOVA used in the present study had one between-subject factor (group) and one repeated or within-subjects factor (the seven success factors). The assumptions for this form of two-way ANOVA are the same as those for one-way repeated measures ANOVA, with the additional assumption of independence between groups. Table 6.3 shows the equations for two-way ANOVA.

Table 6.3 Two way ANOVA General Equations

Source	**Sum of Squares**	**d.f.**	**Mean Square, MS**	**F**
Factor A: Difference between the a machine means $\overline{X}_i$	$SS_A = b\sum_{i=1}^{a} (\overline{X}_{i.} - \overline{\overline{X}})^2$	a – 1	$(SS_A/(a-1))$	$\frac{MS_A}{MS_E}$
Factor B: Difference between the b operator means $\overline{X.j}$	$SS_B = \sum_{j=1}^{b} (\overline{X.j} - \overline{\overline{X}})^2$	b – 1	$MS_B = \frac{SS_B}{b-1}$	$\frac{MS_B}{MS_E}$
Residual (Error): Difference between actual observation X_{ij} and fitted values $\widehat{X}_{ij} = \overline{X}_i + \overline{X}_j - \overline{\overline{X}}$	$SS_B = \sum_{i=1}^{a}\sum_{j=1}^{b}(X_{ij} - \overline{X}_{i.} - \overline{X.j} + \overline{\overline{X}})^2$	(a – 1) x (b -1)	$MS_E = \frac{SS_E}{(a-1)(b-1)}$	
Total	$SS_E = \sum_{i=1}^{a}\sum_{j=1}^{b}(X_{ij} - \overline{\overline{X}})^2$	(ab-1)		
Decision Rule: $F_A > F_{critical}$ ($\alpha = 0.05$, d.f. (a – 1), (a – 1)x(b – 1)) $F_B > F_{critical}$ ($\alpha = 0.05$, d.f. (b – 1), (a – 1)x(b – 1))				

In general, there are three hypotheses tested by the two-way ANOVA. The null hypotheses are as follows:

- The population means of the first factor are equal

- The population means of the second factor are equal
- There is no interaction between the two factors.

In the present study, the first factor (the between subjects factor) is the group, and the second factor (the repeat factor) is the success factor. Therefore, the following three null hypotheses were tested:

- The population means of the groups are equal.
- The population means of the success factors are equal.
- There is no interaction between the effect of group and the effect of the success factor.

H0: $\mu 1=\mu 2=\mu 3=\ldots=\mu is$

H1: not all the μs are equal

Level of significance a = 0.05

6.3 ANALYSIS PROCEDURES

Following is a descriptive summary of the statistical analysis procedures that were used for each part of the general survey to examine the correlation of success factors and delay factors:

- Part 1 (project information): To summarise the response from the project information, frequencies and percentages are used to analyse the result.
- Part 2 (owner information): Frequencies and percentages are used to summarise responses to questions about type of organisation, owner experience, and availability of funding. In the same manner frequencies, percentages and descriptive statistics are used to summarise owners' perceptions of projects (means and standard deviations).
- Part 3 (engineers' information and general experience): Frequencies and percentages are used to summarise background information about engineers. Frequencies, percentages and descriptive statistics (means and standard deviations) are used to summarise engineers' perceptions of the characteristics of public projects.
- Part 4 (contractor information): Frequencies and percentages are used to summarise responses to questions about project payments and

approval of material samples. Frequencies, percentages and descriptive statistics (means and standard deviations) are used to summarise contractors' perceptions of owners.

- Part 5 (project factors evaluation): Pearson correlation coefficient is used to measure the strength and direction of the relationship between critical success and delay factors on the same projects. In addition, a t test was used to examine owners', engineers' and contractors' evaluation of projects' critical success and delay factors.
- Part 6 (Relationship between success and delay factors): A two-way ANOVA is used to examine the mean differences in perceptions between "owners and engineers", "owner and contractors", "contractors and engineers" and "owners, contractors and engineers", to determine which critical success factors had the most influence in avoiding or preventing each delay factor.

6.4. RESULTS AND ANALYSIS

This section will present the characteristics of participants and the results of the Pearson correlations, t and ANOVA tests used to answer the research questions.

6.4.1 Participants' characteristics

One hundred and four responses were received from owners, engineers and contractors who had been involved on construction projects. The descriptive statistics, characteristics and information from the project owners, engineers and contractors meet the requirement of the survey and are discussed as follows:.

6.4.2 Project Information

- Project type: The type of project varied to include office buildings, residences, hospitals, schools, and mixed compounds.
- Project contract type: The sample contained only two types of contracts: lump sum contract and traditional contract.

- Project designer: Projects which were designed in-house by the owner's engineering staff comprised 75 % of the sample, and projects designed by consultants comprised 25 % of the sample.

6.4.3 Owner's Characteristic

- Owners' experience: 65 % of the projects' owners had extensive experience, the remaining had some experience, and none of the respondents were without experience.
- Owner's funding availability: 55% of the sample size had the required project funding fully available, and 45% had funding partially available.

6.4.4 Engineers' Characteristics

- Engineers' information: The researcher sought some information from the engineer respondents about their businesses and experience, in order to clarify ambiguous responses or to compensate for missing data.
- Engineers' academic major: The academic major of the respondent engineers was very important, allowing the researcher to determine whether the information provided was reliable. From among the respondent engineers, 30% were civil engineers who were involved in construction management, 40% were architectural engineers, and 30% of the other engineers were in electrical, mechanical, or urban design areas.
- Engineers' qualifications: The survey showed that 55% of the sample held bachelor's degrees, 40% held master's degrees, and 5% held PhDs.
- Engineers' experience: The experience of the sample engineers varied from a minimum of 10 years, with the most experienced engineer in the sample having 35 years of experience. The mean experience was 20 years.
- Engineers' experience as project manager. The survey showed that 70% of the sample had worked as project managers, and most had worked on at least 60 projects as project managers.

6.4.5 Contractors' Characteristics

- Contractor category: In this study, 60% of the sample contractors were classified as category 6, 20% were category 5 and 20% were classified in the category 4 (The summary of the classification of the categories of contractor can be found on page 98 chapter 5).The contractors' classification process in Brunei requires certain conditions in order to classify the companies, such as their financial situation, key workers' qualifications and equipment and any other owned assets.

6.5 RESEARCH QUESTION TWO

"How are these delays factors correlated to critical success factors within the construction industry?"

Table 6.4 Research Questions 2 (I, II, & III)

Research questions		Answer sought	Statistical method
I	How do specific critical success factors affect individual critical delay factors?	Measurement of the strength and direction of relationship between critical success and delay factors.	A Pearson correlation coefficient was used for each group separately (owners, contractors, and engineers).
II	Do these relations vary by project affiliation ("owner/contractor", "owner/engineer" and "contractor/engineer")?	Comparison of owners', contractors', and engineers' perceptions in both evaluating success and delay factors and influence of success factors on each delay factor	A t-test examining owners', engineers and contractors' evaluation of projects' critical success and delay factors and the influence of critical success factors on critical delay factors
III	Does the ranking of the relative influence of the critical success factors on each critical delay factor vary by project respondents?	Determine if the means differ between responses to the general surveys	One and two – way ANOVA used to examine the means' differences.

This section will provide an explanation of research question two, and the statistical analyses and conclusion. There are three secondary questions used to identify the correlation of critical success factors and delay factors. Table 6.4 summarise the secondary questions for question two, and explains the objective of each question and statistical method used.

6.5.1 Research Question 2 (I)

How do specific critical success factors affect individual critical delay factors?

Determining the relationship between critical success and delay factors in general projects was one of the main goals of this study. In other words, recurring appearances of the success factors with certain delays was sought. In order to answer research question 2, the project critical success and delay factors' evaluation was analysed.

A Pearson correlation coefficient has been used to measure the strength and direction of the relationship between ratings of critical success and delay factors on the projects. The null hypothesis is that the correlation coefficient p is equal to zero. The alternative hypothesis is that p is not equal to zero at a significance level of a + 0.05.

H0: $\rho = 0$

HI: $\rho \neq 0$

$\alpha = 0.05$

6.5.1.1*. *Owners

As shown in Table 6.5 there was a significant correlation between all the seven critical success factors and critical delay factors.

- There is a significant correlation between *organisational planning* (S1) and all seven delay factors.
- There is a significant correlation between the *goal commitment of project manager* (S2) and all seven delay factors.
- A significant correlation exists between *motivation and goal orientation of the project team* (S3) with all seven delay factors.
- There is a significant correlation between the *clarity of the project's scope* (S4) and all seven delay factors.
- There is a significant correlation between the *capability and experience of the project manager* (S5) and all seven delay factors.

- There is a significant correlation between the *safety records* (S6) with all seven delay factors.
- A significant correlation is present between *control system used for the project* (S7) and all seven critical delay factors.

Table 6.5 Correlation coefficient – Success and Delay Factors by Owners

		D1	D2	D3	D4	D5	D6	D7
S1	r	.933**	-.873**	-.855**	-.817**	-.874**	-.860**	-.843**
	p	.000	.000	.000	.000	.000	.000	.000
S2	r	-.897**	.982**	.922**	.949**	.923**	.911**	.907
	p	.000	.000	.000	.000	.000	.000	.000
S3	r	-.933**	.915**	.946**	.929**	.970**	.981*	.932**
	p	.000	.000	.000	.000	.000	.000	.000
S4	r	-.907**	1.000**	.895**	.926**	.970**	.905**	.884**
	p	.000	.000	.000	.000	.000	.000	.000
S5	r	-.897**	.982**	.922**	.949**	.923**	.911*	.907**
	p	.000	.000	.000	.000	.000	.000	.000
S6	r	.893**	.847**	.956**	.912**	.940**	.945**	.946**
	p	.000	.000	.000	.000	.000	.000	.000
S7	r	-.847*	.982**	.922**	.949**	.923**	.911**	.907**
	p	.000	.000	.000	.000	.000	.000	.000
Correlation (r) is significant at a = 0.05 level								

S1 : Organisational planning S2 : Project manager's goal commitment S3 : Project team's motivation and goal orientation S4 : Clarity of the project scope and work definition S5 : Project manager's capabilities and experience S6 : Safety precautions and applied procedures S7 : Use of control system	D1 : Lack of communication between parties D2: Slow decision making D3 : Change orders D4 : Contractor inadequate planning D5 : Finance and payment of completed work D6 : Subcontractors performance D7 : Inadequate contractor experience

6.5.1.2. Contractors

As shown in Table 6.6, there are 43 significant correlations at a = 0.05. (r and p values are listed in table). The correlation between the critical success factors and delay factors are:

Table 6.6 Correlation coefficient – Success and Delay Factors by Contractors

		D1	D2	D3	D4	D5	D6	D7
S1	r	.931**	.926**	.887**	.935**	.864**	.37	.931**
	p	.000	.000	.000	.000	.000	.839	.000
S2	r	.926**	.914**	.896*8	.957**	.881**	.129	.926
	p	.000	.000	.000	.000	.000	.476	.000
S3	r	.927**	.926**	.887**	.935**	.864**	.370	.931*
	p	.000	.000	.000	.000	.000	.839	.000
S4	r	.691**	.684**	.868**	.670**	.816**	.0613**	.681**
	p	.000	.000	.000	.000	.000	.000	.000
S5	r	.864**	.911**	.865**	.916**	.854**	.119	.907**
	p	.000	.000	.000	.000	.000	.510	.000
S6	r	.976**	.935**	.950**	.951**	.940**	.295	.966**
	p	.000	.000	.000	.000	.000	.096	.000
S7	r	1.000**	.997**	.938**	.977**	.921**	.240	1.000
	p	.000	.000	.000	.000	.000	.118	.000
Correlation (r) is significant at a = 0.05 level								
S1 : Organisational planning S2 : Project manager's goal commitment S3 : Project team's motivation and goal orientation S4 : Clarity of the project scope and work definition S5 : Project manager's capabilities and experience S6 : Safety precautions and applied procedures S7 : Use of control system				D1 : Lack of communication between parties D2: Slow decision making D3 : Change orders D4 : Contractor inadequate planning D5 : Finance and payment of completed work D6 : Subcontractors performance D7 : Inadequate contractor experience				

- There are significant correlations between *organisation planning effort (S1), project manager's capabilities and experience (S5)* and *project team motivation (S3) with all* the delay factors, except for delay caused by *subcontractors (D6).*
- There are significant correlations between the *goal commitment of project manager (S2) and use of control system (S7)* and delays associated with *D1, D2, D3, D4, D5, and D7.*
- There are strong correlations between the *clarity of the project scope and work definition (S4)* with all the critical delay factors.
- There are strong correlations between *safety record (S6)* and the delay factors, except the delay factors caused by *subcontractors (D6).*

6.5.1.3. Engineers

As shown in Table 6.7, there was a very strong correlation between all the seven critical success factors and delay factors.

Table 6.7 Correlation Coefficient – Success and Delay Factors by Engineers

		D1	D2	D3	D4	D5	D6	D7
S1	r	.888**	.899**	.898**	.866**	.884**	.900**	.937**
	p	.000	.000	.000	.000	.000	.000	.000
S2	r	.959**	.961**	.977**	.958**	.963**	.994**	.940**
	p	.000	.000	.000	.000	.000	.000	.000
S3	r	.917**	.903**	.912**	.906**	.920**	.928**	.929**
	p	.000	.000	.000	.000	.000	.000	.000
S4	r	.938**	.962**	.946**	.937**	.925**	.955**	.968**
	p	.000	.000	.000	.000	.000	.000	.000
S5	r	.896**	.903**	.898**	.879**	.904**	.908**	.933**
	p	.000	.000	.000	.000	.000	.000	.000
S6	r	.973**	.974**	.957**	.982**	.959**	.948**	.947**
	p	.000	.000	.000	.000	.000	.000	.000
S7	r	.932**	.927**	.938**	.943**	.935**	.934**	.942**
	p	.000	.000	.000	.000	.000	.000	.000
Correlation (r) is significant at a = 0.05 level								

S1 : Organisational planning S2 : Project manager's goal commitment S3 : Project team's motivation and goal orientation S4 : Clarity of the project scope and work definition S5 : Project manager's capabilities and experience S6 : Safety precautions and applied procedures S7 : Use of control system	D1 : Lack of communication between parties D2: Slow decision making D3 : Change orders D4 : Contractor inadequate planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience

6.5.1.4 Conclusion

There is a strong correlation between success factors and delay factors for owners, contractors and engineers. The strong correlations show that owners, engineers and contractors believe that relationships exist between the critical success factors and delay factors, and their results reflect that.

The results show owners and engineers strongly agree that there is a significant correlation between all the critical success factors and all the delay factors. Contractors disagree that any of the critical success factors will help to reduce delay factors caused by *subcontractor performance (D6)* and *inadequate contractor experience (D7).*

6.5.2 *Research Question 2 (II)*

Do the relationships between critical success and delay factors vary by project affiliation (owner/contractor/engineer)? This question examines if there is any difference in how owners, contractors and engineers evaluate individual critical success factors, critical delay factors, and the influence of critical success factors on each delay factor.

An independent sample t test was employed to compare perceptions of "owner and contractor", "owner and engineer" and "contractor and engineer" about critical success factors, critical delay factors, and influence of critical success factors on each of seven critical delay factors in a general project, by comparing their respective response means. The null hypothesis is that the mean responses of owners and contractors are equal, with the significance level, α= 0.05. The means were five points scales where 5 = very good or completely, 4 = good or a good deal, 3 = fair or moderate amount, 2 = poor or small amount and 1= very poor or not at all. Detailed result of t-tests can be found in Appendix B.

6.5.2.1. Owners and Contractors

Critical success factors – (Owners and Contractors)

Ho: μowners=μcontractor

Hı: : μowners ≠=μcontractor

Table (6.8) shows no significant differences in perceptions between owners and contractors. Owners and contractors agree on the importance of the seven critical success factors. Detailed results of the t-test can be found in Appendix B1.

Table 6.8 t test – Critical Success Factors – Owners and Contractors

	S1	S2	S3	S4	S5	S6	S7
Owners	4.033	3.933	3.433	3.967	3.933	3.60	3.933
Contractors	3.879	3.727	3.879	4.061	4.091	3.303	3.455
Where: S1 : Organisational planning S2 : Project manager's goal commitment S3 : Project team's motivation and goal orientation S4: Clarity of projects cope and definition S5 : Project manager's capability and experience S6 : Safety precautions and applied procedures S7 : Use of control system							

Critical delay factors – Owners and Contractors

There were two significant differences in perception between owners and contractors. This is shown in Table 6.9 below.

Table 6.9 t test – Critical Delay Factors – owners and contractors

	D1	**D2**	D3	D4	D5	**D6**	D7
Owner	3.27	**3.97**	3.67	4.03	3.27	**3.33**	3.63
Contractor	3.45	**3.36**	3.03	3.55	2.91	**4.09**	3.45
Shaded : Significant, p<0.05 at a = 0.05							
Where: D1 : Lack of communication between parties D2 : Slow decision making D3 : Change orders D4 : Contractor's inadequate planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience							

The first significant difference was that the mean for the owner was higher than the mean for the contractor for *slow decision making (D2),* indicating that the owner thought (D2) was more important than the contractor did ($t = 2.1$, $p = 0.039$).The second significant difference occurred when the contractor evaluated *subcontractor performance (D6)* higher than the owner did ($t = -2.481$, $p = 0.019$). Contractors blame delays on subcontractors more than owners do. Detailed results of all t-tests can be found Appendix B2.

Differences in the influence of Success Factors on Delay Factors (Owners and Contractors)

Table 6.10 indicates that contractors perceived *project manager's goal commitment (S2)* and *safety precautions and applied procedures (S6),* as being more important in reducing *change orders (D3)* than owners did.

Table 6.10 t test – Owners and Contractors – Influence of Success Factors on Delay Factors

		D1	D2	D3	D4	D5	D6	D7
S1	Owners	3.59	3.24	3.40	3.62	3.12	**3.00**	**3.59**
	Contractors	3.63	3.93	4.20	4.20	3.60	**4.42**	**4.67**
S2	Owners	3.06	3.18	**2.93**	3.22	3.00	**3.07**	2.94
	Contractors	3.32	3.48	**4.00**	4.00	3.40	**4.16**	3.80
S3	Owners	2.59	2.88	3.13	3.28	2.94	2.93	3.53
	Contractors	3.37	3.22	3.75	3.75	3.25	3.26	3.27
S4	Owners	3.18	3.29	3.40	3.50	3.38	**3.21**	3.53
	Contractors	3.47	3.85	3.75	3.75	3.45	**4.16**	3.87
S5	Owners	4.06	3.94	3.47	**3.00**	3.63	**3.07**	**3.76**
	Contractors	3.68	4.41	4.35	**4.35**	4.10	**4.37**	**4.67**
S6	Owners	2.65	2.76	**2.73**	3.00	2.75	2.71	2.71
	Contractors	2.95	2.78	**3.00**	3.00	2.75	3.00	2.53
S7	Owners	3.35	**2.76**	3.20	3,72	3.00	**2.64**	3.41
	Contractors	3.37	**3.63**	4.00	4.00	3.80	**4.00**	4.20

S1 : Organisational planning S2 : Project manager's goal commitment S3 : Project team's motivation and goal orientation S4: Clarity of projects scope and definition S5 : Project manager's capability and experience S6 : Safety precautions and applied procedures S7 : Use of control system	D1 : Lack of communication between parties D2 : Slow decision making D3 : change orders D4 : Inadequate contractor planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience

Contractors also believed that use of *control system (S7)* is more important to reduce *slow decision making (D2)* and *project manager's capability and experience (S5)* is more influential on *inadequate contractor planning (D4).* Similarly contractors evaluated *organisation planning (S1), project manager's goal commitment (S3), clarity of project scope and definition (S4), project manager's capability (S5)* and *use of control system (S7)* as more important in aiding *subcontractors' performance (D6).* Contractors also stated the influence of *organisation planning (S1)* and *project manager's capability (S5)* has a high influence for delay caused by *inadequate contractor experience (D7).* Details of these results can be found in Appendix C1.

6.5.2.2 Owners and Engineers

Critical success factors – (Owners and Engineers)

Ho: μowners=μengineers

Hı: μowners≠μengineers

Table 6.11 shows three significant differences in perception between owners and engineers. The first significant difference is that the mean for owners is higher than the mean for engineers when considering *project manager's goal commitment (S2),* indicating that owners believe *(S2)* to be more important than engineers do.

The second significant difference occurs where the owners rated *clarity of project scope and definition (S4)* higher than engineers did. The owners also rated the third significant difference for *safety precautions (S6)* as more important than engineers did. Details of the t-test results can be found in Appendix B3.

Table 6.11 t test – Critical Success Factors – (Owner and Engineers)

	S1	**S2**	S3	**S4**	S5	**S6**	S7
Owners	4.033	**3.933**	3.433	**3.967**	3.933	**3.60**	3.933
Engineers	4.025	**3.000**	3.725	**3.200**	3,875	**2.675**	3.525
Where: S1 : Organisational planning S2 : Project manager's goal commitment S3 : Project team's motivation and goal orientation S4: Clarity of projects cope and definition S5 : Project manager's capability and experience S6 : Safety precautions and applied procedures S7 : Use of control system							

Critical delay factors – (Owners and Engineers)

Table 6.12 shows the t-test results from owners and engineers. There were three significant differences in perception between owners and engineers on delay factors *slow decision making (D2), change orders (D3)* and *inadequate contractor planning (D4).* The results show that owners believe more strongly than engineers that delays are due to *slow decision making (D2) change orders (D3) and contractor's inadequate planning (D4).* Details of the t-test results can be found in Appendix B4.

Table 6.12 t test – Critical Delay Factors – owners and engineers

	D1	**D2**	**D3**	**D4**	D5	D6	D7
Owner	3.267	**3.967**	**3.667**	**4.033**	3.267	3.333	3.633
Engineers	2.800	**2,800**	**2.900**	**2.800**	.900	2.975	3.350
Shaded : Significant, p<0.05 at a = 0.05							
Where: D1 : Lack of communication between parties D2 : Slow decision making D3 : Change orders D4 : Contractor's inadequate planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience							

Differences in the influence of Success Factors on Delay Factors (Owners and Engineers)

Table 6.13 shows that engineers rated *project team's motivation (S3), clarity of project scope (S4)* and *project manager's capability (S5)* higher than owners did on the influence of delay factors caused *by lack of communication (D1).* Engineers rated *organisational planning (S1), clarity of project scope (S4) and use of control systems (S7)* to avoid delay due to *slow decision (D2),* more highly compared to owners' ratings. Similarly, *organisational planning (S1), project manager's goal commitment (S2), clarity of project scope and definition (S4), safety precaution (S6)* and *use of control system (S7)* has more influence *on change orders (D3),* as rated by engineers compared to owners. Details of the t-test results can be found in Appendix C3.

Table 6.13 t test – Owners and Engineers – Influence of Success Factors on Delay Factors

	Engineers	4.07	**4.16**	**4.56**	3.41	3.22	**4.17**	**4.36**
S2	Owners	3.06	3.18	**3.17**	**3.18**	3.18	3.18	3.18
	Engineers	3.70	3.92	**4.09**	**4.22**	3.08	3.81	3.69
S3	Owners	**2.59**	2.88	2.88	2.88	2.88	2.88	**2.88**
	Engineers	**3.37**	3.21	3.16	2.81	2.94	2.78	**4.03**
S4	Owners	**3.18**	**3.29**	**3.29**	3.29	3.29	3.29	**3.29**
	Engineers	**4.70**	**4.16**	**4.06**	2.81	3.69	3.56	**4.14**
S5	Owners	**4.06**	3.94	3.94	3.94	3.94	3.94	3.94
	Engineers	**4.70**	4.16	4.38	4.28	4.33	4.03	4.31
S6	Owners	2.65	2.76	**2.76**	**2.76**	2.76	2.76	**2.76**
	Engineers	3.17	3.13	**3.53**	**4.28**	2.86	2.78	**3.50**
S7	Owners	3.35	**2.76**	**2,76**	**2.76**	**2.76**	**2.78**	**2.76**
	Engineers	3.70	**3.68**	**4.47**	**3.72**	**3.67**	**3.69**	**4.36**

S1 : Organisational planning S2 : Project manager's goal commitment S3 : Project team's motivation and goal orientation S4: Clarity of projects cope and definition S5 : Project manager's capability and experience S6 : Safety precautions and applied procedures S7 : Use of control system	D1 : Lack of communication between parties D2 : Slow decision making D3 : change orders D4 : Contractor's inadequate planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience

Engineers thought *project manager's goal commitment (S2), safety precaution (S6)* and *use of control systems (S7)* had more effect on *inadequate contractor planning (D4)* than owners did. Engineers rated use of *control systems (S7)* higher than owners did for the delay caused by *finance and payment of completed work (D5). Organisational planning (S1)* and *use of control systems (S7)* were more important to engineers in reducing delay due to *subcontractor performance (D6)* than they were for owners. Engineers rated higher than owners did on the influence of success factors of *organisational planning (S1), project teams (S3), clarity of project scope (S4), safety precaution (S6)* and *use of control systems (S7) for delay caused by inadequate contractor experience(D7).*

6.5.2.3. *Contractors and Engineers*

Critical success factors – (Contractors and Engineers)

Ho: μowners=μengineers

Hı: μowners ≠μengineers

Table 6.14 shows three significant differences. Contractors evaluated *project manager's goal commitment (S2), clarity of project scope (S4)* and *safety precautions (S6)* as more important success factors to avoid delay factors, compared to engineers. Details of the t-test results can be found in Appendix B5.

Table 6.14 t test – Contractors and Engineers

	S1	**S2**	S3	**S4**	S5	**S6**	S7
Contractors	3.879	**3.727**	3.879	**4.061**	4.091	**3.303**	3.454
Engineers	4.025	**3.000**	3.725	**3.200**	3,875	**2.675**	3.525

S1 : Organisational planning
S2 : Project manager's goal commitment
S3 : Project team's motivation and goal orientation
S4: Clarity of project scope and definition
S5 : Project manager's capability and experience
S6 : Safety precautions and applied procedures
S7 : Use of control system

Critical delay factors – (Contractors and Engineers)

For critical delay factors, there were three significant differences in perception between contractors and engineers. Contractors rated *lack of communication between parties (D1), inadequate contractor planning (D4*) and *inadequate contractor experience (D7)* more highly than engineers. Table 6.15 shows results of the critical delay factors survey from contractors and engineers. Details of the t-test results can be found in Appendix B6.

Table 6.15 t test – Critical Delay Factors – contractor and engineers

	D1	D2	D3	**D4**	D5	D6	**D7**
Contractors	**3.454**	3.364	3.030	**3.546**	2.909	4.091	**3.454**
Engineers	**2.800**	2,800	2.900	**2.800**	2.900	2.975	**3.350**
Shaded : Significant, p<0.05 at a = 0.05							
Where: D1 : Lack of communication between parties D2 : Slow decision making D3 : Change orders D4 : Contractor's inadequate planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience							

Differences in the influence of Success Factors on Delay Factors (Contractors and Engineers)

Table 6.16 shows analysis of the results of the t-test from contractors and engineers on the influence of success factors on delay factors. The results shows that engineers evaluated *clarity of project scope (S4)* and *project manager's capability (S5) as* more important than contractors did for the delay factor *lack of communication (D1)*.

Contractors rated *organisational planning (S1), project team motivation (S3),* and *clarity of project scope (S4),* as more influential than engineers, for delay caused by *inadequate contractor planning* (D4) except for *safety precaution (S6)* where engineers rate this more highly than contractors. Engineers rated *project motivation (S3)* and *safety precaution (S6)* as more influential on *inadequate contractor experience (D7)* than did contractors. Details of the t-test results can be found in Appendix C2.

Table 6.16 t test –Influence of Success Factors on Delay Factors for Contractors and Engineers

		D1	D2	D3	D4	D5	D6	D7
S1	Contractors	3.63	3.93	4.20	**4.20**	3.60	4.42	4.67
	Engineers	4.07	4.16	4.56	**3.41**	3.22	4.17	4.36
S2	Contractors	3.32	3.48	4.00	4.00	3.40	4.16	3.80
	Engineers	3.70	3.92	4.09	4.22	3.08	3.81	3.69
S3	Contractors	3.37	3.22	3.75	**3.75**	3.25	3.26	**3.27**
	Engineers	3.37	3.21	3.16	**2.81**	2.94	2.78	**4.03**
S4	Contractors	**3.47**	3.85	3.75	**3.75**	3.45	4.16	3.87
	Engineers	**4.70**	4.16	4.06	**2.81**	3.69	3.56	4.14
S5	Contractors	**3.68**	4.41	4.35	4.35	4.10	4.37	4.67
	Engineers	**4.70**	4.16	4.38	4.28	4.33	4.03	4.31
S6	Contractors	2.95	2.78	3.00	**3.00**	2.75	3.00	**2.53**
	Engineers	3.17	3.13	3.53	**4.28**	2.86	2.78	**3.50**
S7	Contractors	3.37	3.63	4.00	4.00	3.80	4.00	4.20
	Engineers	3.70	3.68	4.47	3.72	3.67	3.69	4.36

S1 : Organisational planning S2 : Project manager's goal commitment S3 : Project team's motivation and goal orientation S4: Clarity of projects cope and definition S5 : Project manager's capability and experience S6 : Safety precautions and applied procedures S7 : Use of control system	D1 : Lack of communication between parties D2 : Slow decision making D3 : change orders D4 : Inadequate contractor planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience

6.5.2.4 Conclusion

The t test results primarily show general agreement - with some differences - in how owners, contractors and engineers evaluated the relations between the critical success factors, critical delay factors and the influence of critical success factors on avoiding each critical delay factor.

For owners and contractors (Table 6.10), there were ten significant correlations out of a possible 49 for the success factor influence in avoiding critical delay factors, indicating general agreement in most cases. The differences occur in the delay factors of *slow decision making (D2), change order (D3), inadequate contractor planning (D4), subcontractor performance (D6),* and *inadequate contractor experience (D7).* The ten significant success factors were evaluated more highly by the contractors than the owners. This shows that, compared to owners, contractors are more convinced that the identified success factors have a greater influence on the delay factors.

Contractors identified the *use of control system (S7)* on delay due to *slow decision making (D2), organisational planning (S1) and safety precaution (S6) on change order (D3), and project manager capability (S5) on contractor's inadequate planning (D4)* as most influential. Similarly, they believed that the success factors: *organisational planning (S1), project manager's goal commitment (S2), clarity of project scope (S4), project manager's capability (S5),* and *use of control system* were more influential on delay due to *subcontractors (D6).* These differences in higher rankings by contractors compared to owners may be explained by their level of involvement in the project, where contractors are more involved than owners. The differences could be that both parties (owners and contractors) tended to evaluate factors related to their own direct interest more highly than the other party.

For owners and engineers (Table 6.13), there are 26 significant correlations. The differences show that engineers believe all the success factors have greater influence on the delay factors than did the owners. For example, engineers believe *organisational planning (S1)* has a greater influence on the delay factors of *slow decision making (D2), change orders (D3), safety precautions (D6)* and *use of control system (D7). Project manager's goal commitment (S2)* is more influential on the delay factors of *change orders (D3)* and *contractor's inadequate planning (D4).*

Similarly, *clarity of project scope and definition* (*S4*) has a higher influence on delay caused by *lack of communication (D1), slow decision making (D2), change orders (D3)* and *inadequate contractor experience (D7).* The success factor of a *project manager's capability (S5)* has a greater influence on the delay factor *lack of communication (D1). Safety precaution (S6)* is ranked higher for delay caused by *change orders (D3), contractors inadequate planning (D4) and inadequate contractor experience (D7).* Engineers also believe the success factor *use of control system (S7)* has a greater influence on all the delay factors except for the delay factor *lack of communication (D1).* These differences may be explained by the level of involvement in the project, with engineers more involved than owners.

For contractors and engineers (Table 6.16), there were eight significant correlations. The differences are engineers ranked highly the success factors: *clarity of project scope and definition (S4) and project manager's capability (S5) for the delay factor lack of communication (D1).* Engineers believe that *safety precaution (S6)* is more important for delay caused by *inadequate contractor planning (D4),* compared with contractors, who believed *organisational planning (S1), project team motivation (S3)* and *clarity of project scope (S4)* have a greater influence. Engineers ranked *project team motivation (S3)* and *safety precaution (S6),* as more influential on the delay factor *inadequate contractor planning (D4)* when compared with contractors' ratings.

Contractors and engineers showed less significant correlations for critical success factors and delay factors, compared to the correlations between owners and contractors, and owners and engineers. This indicates that contractors and engineers agreed with each other more than any other group. Their agreement may be explained by the level of involvement in the project, with both parties more involved than owners.

6.5.3. *Research Question 2 (III) – Individual group*

Does the ranking of the relative influence of critical success factors on each critical delay factor vary between project respondents?

To answer this section's primary question, it was necessary to examine respondents' data from a number of different perspectives, which meant combining or isolating certain groups' results with others. This was done in the following ways:

- Owners, contractors and engineers were examined individually in order to determine which critical success factors they perceived to be most influential in avoiding or preventing each delay factor.
- Owners and contractors, owners and engineers and contractors and engineers were examined collectively to reveal which success factors they perceived most critical in avoiding or preventing each delay factor.

Owners, contractors and engineers were collectively examined in order to discover which critical success factors were most helpful in preventing each delay factor.

6.5.3.1 Owner

Statistical Method

A one-way ANOVA was used to determine the individual owners' perceptions of the seven critical success factors' relative influence on each critical delay factor, through comparison of the critical success factors' means. This statistical measure was also used to assess the remaining groups, contractors and engineers. The null hypothesis is that the mean responses for the seven success factors are equal; the alternative hypothesis is that the mean responses are not equal.

Ho: $\mu_{s1}=\mu_{s2}=\mu_{s3}=\ldots=\mu_{s7}$

H_1 : Not all the μs are equal

Significance level $\alpha = 0.05$

In this section data will be presented for each groups' analysis by providing a general description of the group test, along with which success factors were found to be most influential in avoiding each delay factor. Post-hoc examination was carried out to determine which success factors were most significant in avoiding the same delay factors. Details of one-way Anova results can be found in Appendix D.

Results Description

The data from surveys of owners was evaluated for the influence of success factors in avoiding or preventing delay factors, in order to develop a clearer vision of which success factor are most influential in avoiding or preventing one or more of the delay factors. As shown in Table 6.18 and Table 6.19, the group (owners) evaluation data results such as mean, standard deviation, and group size (n) were extracted from the SPSS output, which computed and tabulated the data in Table 6.17. Data was then sorted by mean from highest to lowest for each delay factor as shown in Table 6.18.

Table 6.17 One-Way ANOVA Results for Owners

Delay 1						Delay 2					
	Mean	St.D	n	Sort	Rank		Mean	St,D	n	Sort	Rank
S1	3.6316	1.46099	19	3.6842	5	S1	3.2353	1.34766	17	3.9412	5
S2	3.3158	1.41628	19	3.6316	1	S2	3.1765	1.23669	17	3.2941	4
S3	3.3684	1.42246	19	3.4737	4	S3	2.8824	1.26897	17	3.2353	1
S4	3.4737	1.54087	19	3.3684	7	S4	3.2941	1.15999	17	3.1765	2
S5	3.6842	1.45498	19	3.3684	3	S5	3.9412	1.24853	17	2.9412	7
S6	2.9474	1.31122	19	3.3158	2	S6	2.7647	1.09141	17	2.8824	3
S7	3.3684	1.34208	19	2.9474	6	S7	2.9412	1.29762	17	2.7647	6
Delay 3						Delay 4					
	Mean	St.D	n	Sort	Rank		Mean	St.D	n	Sort	Rank
S1	3.4000	1.35225	15	3.4667	5	S1	3.6111	1.46082	18	3.7222	7
S2	2.9333	1.27988	15	3.4000	1	S2	3.2222	1.47750	18	3.6111	1
S3	3.1333	1.30201	15	3.4000	4	S3	3.2778	1.44733	18	3.5000	6
S4	3.4000	1.35225	15	3.2000	7	S4	3.5000	1.46528	18	3.2778	3
S5	3.4667	1.45733	15	3.1333	3	S5	3.0000	1.49509	18	3.2222	2
S6	2.7333	1.22280	15	2.9333	2	S6	3.0000	1.49509	18	3.0000	5
S7	3.2000	1.32017	15	2.7333	6	S7	3.7222	1.27443	18	3.0000	6
Delay 5						Delay 6					
	Mean	St.D	N	Sort	Rank		Mean	St.D	n	Sort	Rank
S1	3.1250	1.50000	16	3.6250	5	S1	3.0000	1.35873	14	3.2143	4

S2	3.0000	1.41421	16	3.3750	4	S2	3.0714	1.32806	14	3.0714	2
S3	2.9375	1.52616	16	3.1250	1	S3	2.9286	1.26881	14	3.0714	5
S4	3.3750	1.36015	16	3.0000	2	S4	3.2143	1.42389	14	3.0000	1
S5	3.6250	1.36015	16	3.0000	7	S5	3.0714	1.32806	14	2.9286	3
S6	2.7500	1.41412	16	2.9375	3	S6	2.7143	1.38278	14	2.7143	6
S7	3.0000	1.41259	16	2.7500	6	S7	2.6429	1.27745	14	2.6429	7

Delay 7					
	Mean	St.D	n	Sort	Rank
S1	3.5882	1.27764	17	3.7647	5
S2	2.9412	1.51948	17	3.5882	1
S3	3.5294	1.32842	17	3.5294	3
S4	3.5294	1.46277	17	3.5294	4
S5	3.7647	1.25147	17	3.4118	7
S6	2.7059	1.35852	17	2.9412	2
S7	3.4118	1.32565	17	2.7059	6

S1: Organisational planning
S2: Project manager's goal commitment
S3: Project team's motivation and goal orientation
S4: Clarity of the project scope and work definition
S5: Project manager's capabilities and experience
S6: Safety precautions and applied procedures
S7: Use of Control system

D1 : Lack of communication between parties
D2 : Slow decision making
D3 : Change orders
D4 : Contractor's inadequate planning
D5 : Finance and payment of completed work
D6 : Subcontractor performance
D7 : Inadequate contractor experience

Table 6.18 One-Way ANOVA Summary Results for Owners

	D1	D2	D3	D4	D5	D6	D7
Highest							
S	5	$5^{(6,7)}$	5	7	5	4	$5^{(6)}$
S	1	4	1	1	4	2	1
S	4	1	4	6	1	5	3
S	7	2	7	3	2	1	4
S	3	7	3	2	7	3	7
S	2	$3^{(5)}$	2	5	3	6	2
S	6	6	6	6	6	7	6
Least							

*X means that there are significant differences between two success factors on the same delay factor, x success factor is more influential than y success factor in avoiding the same delay factor

Results of One Way ANOVA

As shown in the Table 6.19, owners rated *project manager capability and experience (S5)* as the most influential factor in avoiding all delay factors except for *inadequate contractor planning (D4)* and *safety precaution and procedures (D5). Organisational planning (S1)* ranked second in avoiding most delay factors. The least influential factors for almost all delay factors was the *safety precaution and applied procedures (S6).* Details of the results of the One Way ANOVA is shown in Appendix D1 and D2.

Post – Hoc Examination - Owners

To determine precisely which success factor is most influential at avoiding or preventing delay factors, post hoc examinations at a = 0.05 comparison reveals significant differences between *project team's motivation and goal orientation (S3), capability and experience of project manager (S5), safety precaution and applied procedure (S6)* and *the use of control system (S7),* all being more influential in the avoidance of *slow decision making (D2),* with the significant difference (p value 0.04, 0.07 and 0.020).

A similar relationship can be observed between *project manager capability and experience (S5*), which was more influential in avoiding *inadequate contractor experience (D7)* than *safety precaution and applied procedure (S6)*. Details of Post-Hoc results are shown in Appendix D3.

Table 6.19 One Way ANOVA Results for Owners (Post – Hoc)

Delay	(I) Success Factor	(J) Success Factor	Mean Difference (I – J)	(p)
D2	3	5	-1.05882	.014
	5	6	1.17647	.007
	5	7	1.00000	.020
D7	5	6	1.05882	.026
*The mean difference is significant at the 0.05 level				

6.5.3.2 Contractors

Table 6.20 shows the results of the one-way ANOVA for contractors. A summary of the result for each delay factor was transformed as shown in Table 6.22. The result of the analysis shows that contractor evaluations for *project manager capability and experience (S5)* is the most influential for most of the delay factors except for the delay factors *subcontractor performance (D6)* and *inadequate contractor experience (D7),* which contractors thought could be best avoided by *organisational planning (S1). Organisational planning (S1)* is ranked second. Contractors indicated the least influential success factors for all the delay factors were *safety precaution and applied procedure (S6).* Detailed results can be found in Appendix D4 and D5.

Table 6.20 One-Way ANOVA Results for Contractors

Delay 1						Delay 2					
	Mean	St.D	n	Sort	Rank		Mean	St,D	n	Sort	Rank
S1	3.5882	1.50245	17	3.8235	5	S1	3.9259	1.41220	27	4.4074	5
S2	3.0588	1.34493	17	3.5882	1	S2	3.4815	1.18874	27	3.9259	1
S3	2.5882	1.32565	17	3.4118	4	S3	3.2222	.93370	27	3.8519	4
S4	3.4118	1.46026	17	3.3529	7	S4	3.8519	1.37851	27	3.6296	7
S5	3.8235	1.46779	17	3.0588	2	S5	4.4074	.88835	27	3.4815	2
S6	2.6471	1.53872	17	2.6471	6	S6	2.7778	.80064	27	3.2222	3
S7	3.3529	1.32009	17	2.5882	3	S7	3.6296	1.07946	27	2.7778	6
Delay 3						Delay 4					
	Mean	St.D	n	Sort	Rank		Mean	St.D	n	Sort	Rank
S1	4.2000	1.00525	20	4.3500	5	S1	4.1250	.95743	16	4.2500	5
S2	4.0000	1.29777	20	4.2000	1	S2	3.0625	1.38894	16	4.1250	1
S3	3.7500	1.16416	20	4.0000	2	S3	3.1250	1.31022	16	3.8125	7
S4	3.7500	1.16416	20	4.0000	7	S4	3.6875	1.01448	16	3.6875	4
S5	4.3500	.98809	20	3.7500	4	S5	4.2500	1.12546	16	3.1250	3
S6	3.0000	1.02598	20	3.7500	3	S6	2.6250	.95743	16	3.0625	2
S7	4.0000	1.21395	20	3.0000	6	S7	3.8125	.91059	16	2.6250	6
Delay 5						Delay 6					
	Mean	St.D	n	Sort	Rank		Mean	St.D	n	Sort	Rank
S1	3.6000	1.39170	20	4.1000	5	S1	4.4211	1.01739	19	4.4211	1
S2	3.4000	1.14248	20	3.8000	7	S2	4.1579	.89834	19	4.3684	5
S3	3.2500	1.25132	20	3.6000	1	S3	3.2632	.87191	19	4.1579	2
S4	3.4500	1.19097	20	3.4500	4	S4	4.1579	.89834	19	4.1579	4
S5	4.1000	1.25237	20	3.4000	2	S5	4.3684	.76089	19	4.0000	7
S6	2.7500	1.25132	20	3.2500	3	S6	3.0000	1.05409	19	3.2632	3

S7	3.8000	1.39925	20	2.7500	6	S7	4.0000	.88192	19	3.0000	6
Delay 7											
	Mean	St.D	n	Sort	Rank						
S1	4.6667	.61721	15	4.6667	1						
S2	3.8000	1.37321	15	4.6667	5						
S3	3.2667	1.38701	15	4.2000	7						
S4	3.8667	1.35576	15	3.8667	4						
S5	4.6667	.89974	15	3.8000	2						
S6	2.5333	.99043	15	3.2667	3						
S7	4.2000	.94112	15	2.5333	6						
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system						D1 : Lack of communication between parties D2 : Slow decision making D3 : change orders D4 : Contractor's inadequate planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience					

Table 6.21 One-Way ANOVA Summary Results for Contractors

	D1	D2	D3	D4	D5	D6	D7
	Highest						
S	$5^{(6)}$	$5^{(6,7)}$	$5^{(6)}$	$5^{(6)}$	$5^{(6)}$	1	1
S	$1^{(3)}$	$1^{(3,6)}$	$1^{(6)}$	$1^{(2,3,6)}$	7	5	5
S	4	$4^{(6)}$	$2^{(6)}$	7	$1^{(6)}$	2	7
S	7	7	7	$4^{(6)}$	4	4	4
S	2	$2^{(5,6)}$	$4^{(6)}$	$3^{(5)}$	2	7	2
S	$3^{(5)}$	$3^{(4)}$	$3^{(6)}$	$2^{(5)}$	$3^{(5)}$	3	3
S	6	$6^{(7)}$	$6^{(7)}$	$6^{(7)}$	$6^{(7)}$	6	6
	Least						
*X means that there are significant differences between two success factors on the same delay factor, x success factor is more influential than y success factor in avoiding the same delay factor							
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system				D1 : Lack of communication between parties D2 : Slow decision making D3 : Change orders D4 : Contractor's inadequate planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience			

Post – Hoc Examination – Contractors

On post hoc examination of the contractor group, as shown in the Table 6.22, all the critical delay factors had significant differences between critical success factors except for *subcontractor performance (D6)* and *inadequate contractor experience (D7)*. Detailed results can be found in Appendix 6.

Table 6.22 One-Way ANOVA Results for Contractors (Post – Hoc)

Delay	(I) Success Factor	(J) Success Factor	Mean Difference (I – J)	(p)
D1	1	3	1.00000	.043
	3	5	-1.23529	.013
	5	6	1.17647	.018
D2	1	3	.70370	.022
	1	6	1.14815	.000
	2	5	- .92593	.003
	2	6	.70370	.022
	3	4	-.62963	.040
	4	6	1.07407	.001
	5	6	1.62963	.000
	5	7	.77778	.012
	6	7	- .85185	.006
D3	1	6	1.20000	.001
	2	6	1.00000	.006
	3	6	.75000	.037
	4	6	.75000	.037
	5	6	1.35000	.000
	6	7	-1.00000	.006
D4	1	2	1.06250	.008
	1	3	1.00000	.012
	1	6	1.500000	.000
	2	5	-1.18750	.003
	3	5	-1.23500	.005
	4	6	1.06250	.008
	5	6	1.62500	.000
	6	7	-1.18750	.003
D5	1	6	.85000	.036
	3	5	-.85000	.036
	5	6	1.35000	.001
	6	7	-1.50000	.010

*The mean difference is significant at the o,o5 level S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system	D1 : Lack of communication between parties D2 : Slow decision making D3 : Change orders D4 : Contractor's inadequate planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience

6.5.3.3 Engineers

Table 6.23 shows the resulting analysis of one-way ANOVA for contractors. A summary of the analysis for each delay factor is shown in Table 6.24. From tables 6.23 and 6.24 it can be seen that engineers evaluate *organisational planning (S1)* as the most influential factor in avoiding delay factors that occur from *slow decision making (D2), change orders (D3), safety precautions (D5) and inadequate contractor experience (D7).*

Similarly, the *capability and experience of the project manager* (S5) in reducing delay factors occurs due to *lack of communication between parties (D1), inadequate contractor planning (D4),* and *finance and payment of completed work (D5). Safety procedure (S6)* was the least influential success factor except for delay due to *change orders (D3)* and *inadequate contractor planning (D4).* Detailed results can be found in Appendix D7 and D8.

Table 6.23 One-Way ANOVA Results for Engineers

Delay 1						Delay 2					
	Mean	St.D	n	Sort	Rank		Mean	St,D	n	Sort	Rank
S1	4.0667	.82768	30	4.7000	5	S1	4.1579	.91611	38	4.1579	1
S2	3.7000	.87691	30	4.3667	4	S2	3.9211	1.30242	38	4.1579	4
S3	3.3667	.92786	30	4.0667	1	S3	3.2015	1.59658	38	4.1579	5
S4	4.3667	.99943	30	3.7000	2	S4	4.1579	.91611	38	3.9211	2
S5	4.7000	.59596	30	3.7000	7	S5	4.1579	.91611	38	3.6842	7
S6	3.1667	1.17688	30	3.3667	3	S6	3.1316	1.43642	38	3.2015	3
S7	3.7000	.87691	30	3.1667	6	S7	3.6842	1.41622	38	3.1316	6
Delay 3						Delay 4					
	Mean	St.D	n	Sort	Rank		Mean	St.D	n	Sort	Rank
S1	4.5625	.61892	32	4.5625	1	S1	3.4063	1.34066	32	4.2813	5
S2	4.0938	1.22762	32	4.4688	7	S2	4.2188	.87009	32	4.2813	6
S3	3.1563	1.32249	32	4.3750	5	S3	2.8125	1.22967	32	4.2188	2
S4	4.0625	1.10534	32	4.0938	2	S4	2.8125	1.22967	32	3.7188	7
S5	4.3750	.79312	32	4.0625	4	S5	4.2813	.99139	32	3.4063	1
S6	3.5313	1.07716	32	3.5313	6	S6	4.2813	1.05446	32	2.8125	3
S7	4.4688	.76134	32	3.1563	3	S7	3.7188	1.08462	32	2.8125	4
Delay 5						Delay 6					
	Mean	St.D	n	Sort	Rank		Mean	St.D	n	Sort	Rank
S1	3.2222	1.56955	36	4.3333	5	S1	4.1667	1.10841	36	4.1667	1
S2	3.0833	1.50000	36	3.6944	4	S2	3.8056	1.19090	36	4.0278	5
S3	2.9444	1.30809	36	3.6667	7	S3	2.7778	1.33333	36	3.8056	2

S4	3.6944	1.47007	36	3.2222	1	S4	3.5556	1.25230	36	3.6944	7
S5	4.3333	.95618	36	3.0833	2	S5	4.0278	1.15847	36	3.5556	4
S6	2.8611	1.41730	36	2.9444	3	S6	2.7778	1.35459	36	2.7778	3
S7	3.6667	1.41421	36	2.8611	6	S7	3.6944	1.26083	36	2.7778	6
Delay 7											
	Mean	St.D	n	Sort	Rank						
S1	4.3611	.86694	36	4.3611	1						
S2	3.6944	1.06421	36	4.3611	7						
S3	4.0278	1.08196	36	4.3056	5						
S4	4.1389	1.09942	36	4.1389	4						
S5	4.3056	.92023	36	4.0278	3						
S6	3.5000	1.10841	36	3.6944	2						
S7	4.3611	.89929	36	3.5000	6						
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system						D1 : Lack of communication between parties D2 : Slow decision making D3 : Change orders D4 : Contractor's inadequate planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience					

Table 6.24 One Way ANOVA Summary Results for Engineers

	D1	D2	D3	D4	D5	D6	D7
Highest							
S	$5^{(6,7)}$	$1^{(3,6)}$	$1^{(3,6}$	$5^{(7)}$	$5^{(6,7)}$	$1^{(3,4,6)}$	$1^{(2,6)}$
S	$4^{(6,7)}$	$4^{(6)}$	7	$6^{(7)}$	$4^{(6)}$	$5^{(6)}$	7
S	$1^{(3,5,6)}$	$5^{(6)}$	$5^{(6)}$	$2^{(3,4)}$	7	$2^{(3,6)}$	$5^{(6)}$
S	$2^{(4,5,6)}$	$2^{(3,6)}$	$2^{(3,6)}$	7	$1^{(5)}$	7	$4^{(6)}$
S	7	7	$4^{(6)}$	$1^{(2,3,4,5,6)}$	$2^{(5)}$	$4^{(6)}$	$3^{(6)}$
S	$3^{(4,5)}$	$3^{(4,5)}$	$6^{(7)}$	$3^{(5,6,7)}$	$3^{(4,5,7)}$	$3^{(45,7)}$	$2^{(5,7)}$
S	$6^{(7)}$	6	$3^{(4,5,7)}$	$4^{(5,6,7)}$	$6^{(7)}$	$6^{(7)}$	$6^{(7)}$
Least							
*X means that there are significant differences between two success factors on the same delay factor, x success factor is more influential than y success factor in avoiding the same delay factor							
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of control systems				D1 : Lack of communication between parties D2 : Slow decision making D3 : Change orders D4 : Inadequate contractor planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience			

Post – Hoc Examination – Engineer

Table 6.25 shows the results of post-hoc examinations for engineers, which demonstrate that engineers have identified a significant difference for all the critical success factors and critical delay factors. (Detailed results can be found in Appendix D9)

Table 6.25 One Way ANOVA Results for Engineers (Post – Hoc)

Delay	(I) Success Factor	(J) Success Factor	Mean Difference (I – J)	(p)
D1	1	3	.70000	.003
	1	5	-.63333	.008
	1	6	.90000	.000
	2	4	-.66667	.005
	2	5	-1.00000	.000
	2	6	.53333	.025
	3	4	-1.00000	.000
	3	5	-1.33333	.000
	4	6	1.20000	.000
	4	7	.66667	.005
	5	6	1.53333	.000
	5	7	1.00000	.000
	6	7	-.53333	.025
D2	1	3	.94737	.001
	1	6	1.02362	.000
	2	3	.71053	.013
	2	6	.78947	.006
	3	4	-.94737	.001
	3	5	-.94737	.001
	4	6	1.02632	.000
	5	6	1.02632	.000
D3	1	3	1.40625	.000
	1	6	1.03125	.000
	2	3	.93750	.000
	2	6	1.03125	.028
	3	4	-.90625	.000
	3	5	-1.21875	.000
	3	7	-.37500	.000

	4	6	.53125	.038
	5	6	.84375	.001
	6	7	-.93750	.000
D4	1	2	-.81250	.004
	1	3	.59375	.036
	1	4	.59375	.036
	1	5	-.87500	.002
	1	6	-.87500	.002
	2	3	1.40625	.000
	2	4	.59375	.036
	3	5	-1/46875	.000
	3	6	-1.46875	.000
	3	7	-.90625	.001
	4	5	-1.46875	.000
	4	6	-1.46875	.000
	4	7	-.90625	.001
	5	7	.56250	.047
	6	7	.56250	.047
D5	1	5	-1.11111	.001
	2	5	-1.25000	.000
	3	4	-.75000	.023.
	3	5	-1.38889	.000
	3	7	-.72222	.028
	4	6	.83333	.012
	5	6	1.47222	.000
	5	7	..6667	.043
	6	7	-.80556	.015
D6	1	3	1.38889	.000
	1	4	.61111	.038
	1	6	1.38889	.000
	2	3	1.02778	.001
	2	6	1.02778	.001
	3	4	-.77778	.008
	3	5	-1.25000	.000
	3	7	-.91667	.002
	4	6	.7778	.008
	5	6	1.25000	.000
	6	7	-.91667	.002
D7	1	2	.66667	.006

	1	6	.86111	.000
	2	5	-.61111	.000
	2	7	-.66667	.006
	3	6	.52778.	.028
	4	6	.63889	.008
	5	6	.80556	.001
	6	7	-.86111	.000

*The mean difference is significant at the o,o5 level S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of control system	D1 : Lack of communication between parties D2 : Slow decision making D3 : Change orders D4 : Contractor's inadequate planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience

6.5.3.4. *Conclusion*

Testing each respondent's group separately using a one-way ANOVA revealed some agreement between owners, contractors and engineers, especially for the most critical success factor influences. It is clear that a *project manager's capability and experience (S5)* was the most influential success factor for all groups, and there was strong agreement between all groups that *safety precaution and procedures (S6)* was the least influential success factor.

Owners and contractors differed with regards to which success factors were most influential in helping to avoid delays caused by *inadequate contractor planning (D4), subcontractor performance (D6),* and *inadequate contractor experience (D7).* Owners believed the *use of control system (S7*) would help to remedy these delays, while contractors believed that the *project manager's capabilities (S5)* had a significant influence on *contractor's inadequate* *planning (D4*) and *organisational planning (S1)* for delays caused by *subcontractor performance (D6)* and *inadequate contractor experience (D7).* Engineers agreed with the contractors' opinion that the *project manager's capabilities (S5)* are highly influential on *contractor's inadequate planning (D4) and organisational planning (S1*) for delays caused by *subcontractors (D6) and inadequate contractor experience (D7).*

When compared to contractors and engineers, contractors believed a *project manager's capability (S5)* was the most influential factor in reducing delay factors caused by *slow decision making (D2)* and *change orders (D3),* compared to engineers who believed *organisational planning (S1)* was the most influential in reducing delay factors caused by *slow decision making (D2)* and *change orders (D3).*

For delay factors, D3 and D4, contractors thought *safety precaution (S6)* was the least influential factor, which differed to engineers who believe *project team motivation and goal orientation (S5) and clarity of project scope and definition (S3)* were least influential in avoiding delay factors caused by *change orders (D3) and inadequate contractor planning (D4).*

Owners and engineers differed in their ranking for delay factors *slow decision making (D2), change orders (D4), subcontractors (D6),* and *inadequate contractor experience (D7).* Owners believed a *project manager's capability (S5)* will help to reduce these delays while engineers believed that *organisational planning (S1)* was more influential in avoiding those delays. For delays caused by *inadequate contractor experience (D7),* owners believed *use of control system (S7)* would help to reduce delays while engineers believed *project manager's capabilities (S5)* would help to reduce these delays. Owners thought that *project manager's capabilities (S5)* was the most important success factor for the delay factor *inadequate contractor experience (D7),* compared to engineers who ranked *organisational planning effort (S1)* as most important for this delay factor.

The difference in the least influential factor was examined from owners', contractors' and engineer' perspectives. One way ANOVA results demonstrated significant differences for the delay factors *change orders (D3), inadequate contractor planning (D4),* and *subcontractors (D6*). Owners believed *safety precautions (S6)* was the least influential factor for *change orders (D3) and inadequate contractor planning (D4), and use of control system (S7)* for the delay factor *subcontractor performance (D6).* Engineers believed *project's team motivation (S3*) was the least influential for delay factors *change orders (D3), clarity of project scope (S4), inadequate contractor planning (D4*) and *safety precaution (S6)* for delays caused by the subcontractor. Contractors strongly believed that *safety precaution (S6)* was the least influential success factor for all the delay factors.

Generally all three groups were in agreement regarding the greatest influential success factors and least influential success factors at avoiding delay factors, with minor agreement in the middle range. The differences in opinion may be due to the fact that owners tend to view problems from a top down approach and are not solely focussed on the project construction process. Engineers show more concern for the success factors *safety precaution (S6)* on delay factors, and this may be because engineers take safety precautions more seriously compared to owners and contractors, since they are concerned about the potential delays caused by safety mishaps. Additionally, the nature of their work causes them to be concerned with safety.

Contractors and engineers showed more significance in the ranking of success factors' influence when compare to owners. This is also shown in the contractors and engineers Post Hoc results. Results showed more significance in the ranking of critical success factors by contractors and engineers than by owners (see Post-hoc results at appendix B, C, and D). This may be because contractors and engineers were closer to the project process environment, and therefore possessed a clearer knowledge of the field and construction processes than did owners.

6.5.4. *Research Question 2(III) – Combined Groups*

In order to compare the responses of all groups, three separate groups of two way ANOVA tests were conducted. These tests examined the differences among groups: owners and contractors; owners and engineers; contractors and engineers; and owners, contractors and engineers, in order to pinpoint the perception of relative influence for the seven critical success factors on each individual critical delay factor by comparing means.

Statistical Method – Two Way ANOVA

Critical factors relationships were tested between groups by using a two-way analysis of variance (ANOVA), which compared how the groups perceive the relative influence of all seven critical success and delay factors by comparing their means. In order to determine which factors were most influential in preventing each delay factor, this test also examined the success factors effect, main group effect, and group by success factors (interaction).

- Success Factors Effect: This test examined whether or not the two groups as a whole thought some success factors had more or less influence than others to prevent or avoid each of the seven delay factors, which can be observed through post-hoc analysis. The null hypothesis is that the mean responses for the seven success factors are equal; the alternative hypothesis is that the mean responses are not equal for each participating group:

  $H0{:}\mu s1=\mu s2=\mu s3=\ldots=s7$

  $H\imath$: not all the μs is equal

- Group Main Effect: This test examined whether one group (i.e. owners vs contractors, owners vs engineers and contractors vs engineers) think that the success factors as a whole, i.e., the seven success factors together, have more influence than the other group, on each of the seven delay factors.

Ho:[(μsı0wners+μs20wners+…+μs7owners)/7]=[(μs1contractors+μs2 contractors +……+ μs7 contractors)/7]

H1:[(μs1owners+μs2owners+…+μs7owners)/7]≠[(μs1contractors+μs2 contractors+…+μs7contractors)/7]

Significance level α = 0.05

- Group by Success Factors (Interaction): This test determined whether the ranking of success factors for a particular delay is different or the same across the two groups. If the rankings are very similar, the interaction will not be significant. The null hypothesis is that the ranking for success factors between two groups are equal; the alternative hypothesis is that the ranking is not equal. For each delay factor (D1 to D7):

  Ho:[(Ranksı0wners=Ranks1contractors…,Ranks7owners = Ranks7contractors

  Ho:[(Ranksı0wners≠Ranks1contractors…,Ranks7owners ≠ Ranks7contractors

  Significance level α = 0.05

6.5.4.1. Owners and Contractors

As stated earlier, the aim is to gather the opinions of the response groups individually, as well as collectively in order to examine their similarities and differences, which could then lead to a more detailed examination of the relationship between success and delay factors. In this section data from the tests and their results will be presented in the form of results describing success factors effect, group main effect, interaction and a conclusion for all the group cases. (Detailed Two Way ANOVA results are shown in Appendix E1).

Table 6.26 Two-Way ANOVA Analysis Results Summary for Owners and Contractors

Source	D1	D2	D3	D4	D5	D6	D7
Success Factors	NO	YES	YES	YES	YES	YES	YES
Group	NO	YES	YES	NO	YES	YES	YES
Interaction	NO	YES	NO	YES	NO	NO	YES

D1 : Lack of communication between parties
D2 : Slow decision making
D3 : Change orders
D4 : Contractor's inadequate planning
D5 : Finance and payment of completed work
D6 : Subcontractor performance
D7 : Inadequate contractor experience

Results Described

By examining owners' and contractors' data collectively, as shown in Table 6.26, the results demonstrate that there is a success factors' main effect for all success factors in avoiding most delay factors, except for *lack of communication between parties (D1).* There was a group main effect for *slow decision making (D2), change orders (D3), finance and payment of completed work (D5), subcontractor performance (D6)* and *inadequate contractor experience (D7),* and two group by factors interaction for inadequate *contractor planning (D4)* and *inadequate contractor experience (D7).*

An examination of the two way ANOVA results in table 6.27 not only shows that certain critical success factors were seen as having a greater influence in preventing individual critical delay factors, but that the pattern of results was very similar across all seven delay factors. Specifically, respondents indicated that *project manager capability and management (S5*) and *organisational planning (S1)* are the most influential factors in preventing nearly all seven delay factors. Similarly *safety precaution and applied procedure (S6)* was seen as the least influential factors in preventing the seven delay factors.

Table 6.27 Two Way ANOVA Results for Owners and Contractors

	D1	D2	D3	D4	D5	D6	D7
	Highest						
S	$5^{(3,6)}$	$5^{(6,7)}$	$5^{(6)}$	$1^{(3,4,5)}$	$5^{(6)}$	$5^{(6)}$	$5^{(6)}$
S	$1^{(6)}$	$1^{(3,5,6)}$	$1^{(6)}$	7	$4^{(6)}$	$1^{(3,6)}$	$1^{(3,6)}$
S	4	$4^{(5,6)}$	7	$5^{(6,7)}$	7	$4^{(6)}$	7
S	7	$2^{(5,6)}$	$4^{(6)}$	$4^{(5,6,7)}$	$1^{(6)}$	$2^{(3,6)}$	$4^{(6)}$
S	2	7	$2^{(6)}$	$3^{(5,6,7)}$	$2^{(5)}$	7	3
S	3	$3^{(4,5)}$	$3^{(6)}$	$2^{(3,4,5)}$	$3^{(5)}$	$3^{(4,5)}$	$2^{(6)}$
S	6	$6^{(7)}$	$6^{(7)}$	6	$6^{(7)}$	$6^{(7)}$	$6^{(7)}$

S1: Organisational planning
S2: Project manager's goal commitment
S3: Project team's motivation and goal orientation
S4: Clarity of the project scope and work definition
S5: Project manager's capabilities and experience
S6: Safety precautions and applied procedures
S7: Use of control system

D1 : Lack of communication between parties
D2 : Slow decision making
D3 : Change orders
D4 : Contractor's inadequate planning
D5 : Finance and payment of completed work
D6 : Subcontractor performance
D7 : Inadequate contractor experience

Success Factors Effect

Results of each of the seven individual 2 (Group) x 7 (Success Factor) two-way ANOVA tests demonstrated a significant effect for success factors (range of result: $F (6,322) = 5.909$, $p < 0.001$ to $F (6,231) =3.595$, $p < .019$, a =0.5). That is, for each of the seven delay factors, respondents identified differences in the influence of the seven critical success factors on each critical delay factor.

Group Main Effect

The examination of the main effect for groups reveals significant effects for slow decision making (D2), change orders (D3), finance and payment of completed work (D5), subcontractor performance (D6) and inadequate contractor experience (D7). Contractors evaluated the combined influence of success factors as more influential in preventing delay caused by slow decision making (D2), change orders (D3), finance and payment of completed work (D5), subcontractor performance (D6) and inadequate contractor experience (D7), than did owners. Table 6.28 shows the results of the main effect from the perception of owners and contractors. Detail of each delay factor on group main effect is shown in Tables 6.28a, 6.28b, 6.28c, 6.28d and 6.28e. (Detailed main effect results can be found in Appendix E2)

Table 6.28 Group Main Effect (Owners and Contractors)

DF	(I) GROUP	(J) GROUP	Mean (I – J)	Sig. (p)
D2	3.6138	3.1765	.4973	.002
D3	3.8643	3.1810	.6833	.000
D5	3.4786	3.1161	.3625	.034
D6	3.9098	2.9490	.9608	.000
D7	3.8571	3.3529	.5042	.000
D1 : Lack of communication between parties D2 : Slow decision making D3 : Change orders D4 : Contractor's inadequate planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience				

Table 6.28a Group Main Effect (Owners and Contractors)-D2

Delay 2 (Slow decision making)						
	Owner n = 17		Contractor n= 27		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.2353	1.34766	3.9259	1.41220	3.5806	5
2	3.1765	1.23669	3.4815	1.18874	3.3290	1
3	2.8824	1.26897	3.2222	.93370	3.0523	4
4	3.2941	1.15999	3.8519	1.37851	3.5730	2
5	3.9412	1.24853	4.4074	.88835	4.1743	7
6	2.7647	1.09141	2.7778	.80064	2.7713	3
7	2.9412	1.29762	3.6296	1.07946	3.2854	6
M	**3.1765**		**3.6138**			
Where SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of control system						

Table 6.28b Group Main Effect (Owners and Contractors)-D3

Delay 3						
	Owner n =15		Contractor n= 20		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.4000	1.35225	4.2000	1.00525	3.8000	5
2	2.9333	1.27988	4.0000	1.29777	3.4667	1
3	3.1333	1.30201	3.7500	1.16416	3.4417	7
4	3.4000	1.35225	3.7500	1.16416	3.5750	4
5	3.4667	1.45733	4.3500	.98809	3.9084	2
6	2.7333	1.22280	3.0000	1.02598	2.8667	3
7	3.2000	1.32017	4.0000	1.21395	3.6000	6
M	**3.1810**		**3.8643**			

Where
SF : Success Factors, ST,D : Standard Deviation
Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)

S1: Organisational planning
S2: Project manager's goal commitment
S3: Project team's motivation and goal orientation
S4: Clarity of the project scope and work definition
S5: Project manager's capabilities and experience
S6: Safety precautions and applied procedures
S7: Use of control system

Table 6.28c Group Main Effect (Owners and Contractors)-D5

Delay 5						
	Owner n = 16		Contractor n= 20		Marginal mean owner + contractor)/2	Sorting Highest to lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.1250	1.50000	3.6000	1.39170	3.3625	5
2	3.0000	1.41421	3.4000	1.14248	3.2000	4
3	2.9375	1.52616	3.2500	1.25132	3.0938	7
4	3.3750	1.36015	3.4500	1.19097	3.4125	1
5	3.6250	1.36015	4.1000	1.25237	3.8625	2
6	2.7500	1.39044	2.7500	1.25132	2.7500	3
7	3.0000	1.41421	3.8000	1.39925	3.4000	6
M	**3.1161**		**3.4786**			

Where
SF : Success Factors, ST,D : Standard Deviation
Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)

S1: Organisational planning
S2: Project manager's goal commitment
S3: Project team's motivation and goal orientation
S4: Clarity of the project scope and work definition
S5: Project manager's capabilities and experience
S6: Safety precautions and applied procedures
S7: Use of control system

Table 6.28d Group Main Effect (Owners and Contractors)-D6

Delay 6						
	Owner n = 14		Contractor n=		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.0000	1.35873	4.4211	1.01739	3.7106	5
2	3.0714	1.32806	4.1579	.89834	3.6147	1
3	2.9286	1.26881	3.2632	.87191	3.0959	4
4	3.2143	1.42389	4.1579	.89834	3.6861	2
5	3.0714	1.32806	4.3684	.76089	3.7199	7
6	2.7143	1.38278	3.0000	1.05409	2.8572	3
7	2.6429	1.27745	4.0000	.88192	3.3215	6
M	**2.9490**		**3.9098**			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of control system						

Table 6.28e Group Main Effect (Owners and Contractors)-D7

Delay 7						
	Owner n = 17		Contractor n= 15		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.5882	1.27764	4.6667	.61721	4.1275	5
2	2.9412	1.51948	3.8000	1.37321	3.3706	1
3	3.5294	1.32842	3.2667	1.38701	3.3981	7
4	3.5294	1.46277	3.8667	1.35576	3.6981	4
5	3.7647	1.25147	4.6667	.89974	4.2157	3
6	2.7059	1.35852	2.5333	.99043	2.6196	2
7	3.4118	1.32565	4.2000	.94112	3.8059	6
M	**3.3529**		**3.8571**			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of control system						

Group by Success Factors (Interaction)

Tables 6.29, 6.29a and 6.29b show there were significant group by success factor interactions in the case of *slow decision making (D2), inadequate contractor planning (D4)* and *inadequate contractor experience (D7).* An examination of post-hoc comparison suggests that the relative ranking of influence for each of seven success factors in preventing *slow decision making (D2), inadequate contractor planning (D4*) and *inadequate contractor experience (D7)* was viewed differently by owners and contractors.

Owners considered *clarity of project scope of work (S4)* and *project manager's goal commitment (S2)* more influential than did contractors, and contractors ranked *organisational planning (S1) and safety precaution* and *applied procedure (S7)* as more influential than did owners. Owners and contractors agreed that *project manager's capability and experience (S5)* is the most influential success factor, and *project team's goal and motivation (S3) and project manager's capabilities and experience (S6)* are the least influential success factors for *slow decision making (D2).*

Owners identified *safety precautions (S7)* as the most influential success factor for *inadequate contractor planning (D4),* while contractors believed *project manager capabilities and experience (S5)* was the most influential factor for *inadequate contractor planning (D4).* Owners also believed that *project manager goal commitments (S2), project team's motivation and goal orientation (S3)* and *clarity of project scope and work definition (S4*) to be more influential than did contractors.

For *inadequate contractor experience (D7*), owners believed *organisational planning (S1)* and *project team's motivation and goal orientation (S3)* were more influential to avoid *inadequate contractor experience (D7)* than did contractors, whilst contractors thought *safety precaution (S7)* and *project manager's goal commitment (S2)* were more influential than did owners. Both groups agreed that *project manager's capabilities and experience (S5)* was the most influential success factor, whilst *safety precautions and applied* *procedure (S6)* was the least influential success factor for *inadequate contractor experience (D7).*

Table 6.29 Interaction in D2

Owners D2				Contractors D2			
SF	Mean	Sorting	Ranking	Ranking	Sorting	Mean	SF
1	3.2353	3.9412	S5	S5	4.4074	3.9259	1
2	3.1765	3.2941	S4	S1	3.9259	3.4815	2
3	2.8824	3.2353	S1	S4	3.8519	3.2222	3
4	3.2941	3.1765	S2	S7	3.6296	3.8519	4
5	3.9412	2.9412	S7	S2	3.4815	4.4074	5
6	2.7647	2.8824	S3	S3	3.2222	2.7778	6
7	2.9412	2.7647	S6	S6	2.7778	3.6296	7
Data reading direction				Data reading direction			
SF : Success Factors, Sort : Descending from greatest to least Ranking: Exact hierarchy of importance							
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system							

Table 6.29a Interaction in D4

Owners D4				Contractors D4			
SF	Mean	Sorting	Ranking	Ranking	Sorting	Mean	SF
1	3.6111	3.7222	S7	S5	4.2500	4.1250	1
2	3.2222	3.6111	S1	S1	4.1250	3.0625	2
3	3.2778	3.5000	S4	S7	3.8125	3.1250	3
4	3.5000	3.2778	S3	S4	3.6875	3.6875	4
5	3.0000	3.2222	S2	S3	3.1250	4.2500	5
6	3.0000	3.0000	S5	S2	3.0625	2.6250	6
7	3.7222	3.0000	S6	S6	2.6250	3.8125	7
Data reading direction				Data reading direction			
SF : Success Factors, Sort : Descending from greatest to least Ranking: Exact hierarchy of importance							
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system							

Table 6.29b Interaction in D7

Owners D7				Contractors D7			
SF	Mean	Sorting	Ranking	Ranking	Sorting	Mean	SF
1	3.5882	3.7647	S5	S5	4.6667	4.1275	1
2	2.9412	3.5882	S1	S7	4.2000	3.8000	2
3	3.5294	3.5294	S3	S1	4.1275	3.2667	3
4	3.5294	3.5294	S4	S4	3.8667	3.8667	4
5	3.7647	3.4118	S7	S2	3.8000	4.6667	5
6	2.7059	2.9412	S2	S3	3.2667	2.5333	6
7	3.4118	2.7059	S6	S6	2.5333	4.2000	7
Data reading direction				Data reading direction			
SF : Success Factors Sort : Descending from greatest to least Ranking: Exact hierarchy of importance							

6.5.4.2 Contractor and Engineer

Results Described

By examining contractor and engineer data collectively as shown in Table 6.30, results showed the existence of a success factors' main effect for all success factors in avoiding most delay factors. There was a group main effect for *lack of communication between parties (D1), change orders (D3),* and *subcontractor performance (D6),* and two group by factors interaction *for inadequate contractor planning (D4)* and *inadequate contractor experience (D7*). Detailed results can be found in Appendix E4, E5 and E6.

Table 6.30 Two-Way ANOVA Analysis Results Summary for Contractors and Engineers

Source	D1	D2	D3	D4	D5	D6	D7
Success Factors	YES	YES	YES	YES	YES	YES	YES
Group	YES	NO	YES	NO	NO	YES	NO
Interaction	NO	NO	NO	YES	NO	NO	TES
D1 : Lack of communication between parties D2 : Slow decision making D3 : change orders D4 : Contractor's inadequate planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience							

An examination of the two way ANOVA results in table 6.31 shows that certain critical success factors were seen as having a greater influence in preventing critical delay factors.

Table 6.31 Two-Way ANOVA Results for Contractors and Engineers

	D1	D2	D3	D4	D5	D6	D7
	Highest						
S	$5^{(6,7)}$	5	$1^{(6)}$	$5^{(6,7)}$	$5^{(6,7)}$	$1^{(3,4,6,7)}$	$5^{(6)}$
S	$4^{(6)}$	$1^{(3,6)}$	$5^{(6)}$	$1^{(3,4,5)}$	7	$5^{(6)}$	$1^{(2,3,6)}$
S	$1^{(3,5,6)}$	$4^{(6)}$	7	7	$4^{(5,6)}$	$2^{(3,6)}$	7
S	7	$2^{(3,5,6)}$	$2^{(6)}$	$2^{(3,4)}$	$1^{(5,6)}$	7	$4^{(6)}$
S	$2^{(4,5,6)}$	7	$4^{(5,6)}$	6	$2^{(5,7)}$	$4^{(5,6)}$	$2^{(5,6,7)}$
S	$3^{(4,5,7)}$	$3^{(4,5,7)}$	$3^{(5,6)}$	$4^{(5,6,7)}$	$3^{(5,7)}$	$3^{(4,5,7)}$	$3^{(5,6,7)}$
S	$6^{(7)}$	$6^{(7)}$	$6^{(7)}$	$3^{(5,6)}$	$6^{(7)}$	$6^{(7)}$	$6^{(7)}$

S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system	D1 : Lack of communication between parties D2 : Slow decision making D3 : change orders D4 : Contractor's inadequate planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience

Specifically, respondents indicated that *project manager's capability and experience (S5)* is the most influential success factor to avoid delay factors, except for *change orders (D3)* and *subcontractor performance (D6),* where they indicated *organisational planning (S1)* is the most influential factor. Similarly, both groups agreed that *safety precaution and procedures (S6)* is the least influential factor for all delay factors.

Success Factors Effect

The results of each seven individual 2 x (Group) x 7 (Success factor) two-way ANOVA tests demonstrated a significant effect for success factors (range of results : $f(6,441) = 9.890$, $p < 0.001$ to $f(6,322) = 5.909$, $p < 0.001$). For each of seven delay factors, respondents identified differences in the influence of the seven critical success factors on each critical delay factor.

Group Main Effect

The examination of the main effect for groups reveals there are significant differences for *lack of communication (D1)* and *change orders (D3).* The engineers indicated the combined influence of success factors is more influential in preventing *lack of communication between parties (D1)* and *change orders (D3)* than did the contractors. This is shown in Table 6.32 on the result of group main effect from contractors and engineers. Details of group main effects on D1 and D3 are shown in Table 6.32a and 6.32b.

Table 6.32 Group Main Effect (Contractor and Engineer)

DF	(I) GROUP	(J) GROUP	Mean (I – J)	Sig. (p)
D1	3.8667	3.2101	0.6566	.000
D3	4.0357	3.8643	0.1714	.000

Table 6.32a Group Main Effect (Contractor and Engineer)-D1

Delay 1 (Lack of communication between parties)						
	Contractor n = 17		Engineer n= 30		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.5882	1.50245	4.0667	.82768	3.8275	4
2	3.0588	1.34493	3.7000	.87691	3.3794	1
3	2.5882	1.32565	3.3667	.92786	2.9775	7
4	3.4118	1.46026	4.3667	.99943	3.8893	2
5	3.8235	1.46779	4.7000	.59596	2.8586	3
6	2.6471	1.53872	3.1667	1.17688	2.9069	6
7	3.3529	1.32009	3.7000	.87691	3.5265	5
M	3.2101		3.8667			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system						

Table 6.32b Group Main Effect (Contractor and Engineer)-D3

Delay 3						
	Contractor n = 20		Engineer n= 32		Marginal mean owner + contractor)/ 2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	4.2000	1.00525	4.5625	.61892	4.3813	1
2	4.0000	1.29777	4.0938	.22762	4.0469	5
3	3.7500	1.16416	3.1563	1.32249	3.4532	7
4	3.7500	1.16416	4.0625	1.10534	3.9063	2
5	4.3500	.98809	4.3750	.79312	4.3625	4
6	3.0000	1.02598	3.5313	1.07716	3.2657	3
7	4.0000	1.21395	4.4688	.76134	4.2344	6
M	3.8643		4.0357			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system						

Group by Success Factors (Interaction)

Table 6.33 and 6.33a show the results of group by success factor interaction. There was a significant group by success factor interaction in the case of *inadequate contractor planning (D4)* and *inadequate contractor experience (D7).* An examination of the post-hoc comparison suggests that the relative ranking of influence for each seven factors in *preventing inadequate contractor planning (D4)* and *inadequate contractor experience (D7)* was viewed differently by contractors and engineers.

Contractors *believed organisational planning (S1) and clarity of project scope* and *work definition (S4)* are more influential in avoiding the delay factor *inadequate contractor planning (D4),* than did engineers. Engineers believed that the *project manager's goal commitment (S2), use of control systems (S7)* and *safety precautions (S6)* were more influential in avoiding delay factors than did contractors. Contractors indicated that *safety precaution (S6)* is the least influential factor, whilst engineers indicated that *project team's motivation (S3)* is the least influential factor in avoiding the delay factor *inadequate contractor planning (D4).*

Contractors believed that the *project manager's capabilities and experience (S5),* and *use of control systems (S7)* are more influential in avoiding delays caused by *inadequate contractor experience (D7*) than did the engineers. Both groups believed the most influential factor in avoiding the delay caused by *inadequate contractor experience (D7)* is *organisational planning (S1),* and the least influential factors are *safety precautions and applied procedures (S6).*

Table 6.33 Interaction in D4 (Inadequate contractor planning)

Contractor D4				Engineer D4			
SF	Mean	Sorting	Ranking	Ranking	Sorting	Mean	SF
1	4.1256	4.2500	S5	S5	4.2813	3.4063	1
2	3.0625	4.1250	S1	S2	4.2188	4.2188	2
3	3.1250	3.6875	S4	S7	3.7657	2.8125	3
4	3.6875	3.5268	S7	S6	3.7188	2.8125	4
5	4.2500	3.1250	S3	S1	3.4063	4.2813	5
6	2.6259	3.0625	S2	S4	2.8125	3.7188	6
7	3.5268	2.6259	S6	S3	2.8125	3.7657	7
Data reading direction				Data reading direction			
SF : Success Factors, Sort : Descending from greatest to least Ranking: Exact hierarchy of importance							
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system							

6.5.4.3 *Owner and Engineer*

Results Description

By examining the owner and engineer data collectively, Table 6.34 shows that there is a success factors' main effect for all success factors in avoiding all delay factors. There was a group main effect for all delay factors except for *finance and payment of completed work (D5)* and only one group interaction, *inadequate contractor planning (D4).* Detailed results can be found in Appendix E7, E8 and E9.

Table 6.33a Interaction in D7 (Inadequate contractor experience)

ContractorD7				EngineerD7			
SF	Mean	Sorting	Ranking	Ranking	Sorting	Mean	SF
1	4.6667	4.6667	S1	S1	4.3611	4.3611	1
2	3.8000	4.6667	S5	S7	4.3611	3.6944	2
3	3.2667	4.2000	S7	S5	4.3056	4.0278	3
4	3.8867	3.8667	S4	S4	4.1387	4.1389	4
5	4.6667	3.8000	S2	S3	4.0278	4.3056	5
6	2.5333	3.2667	S3	S2	3.6244	3.5000	6
7	4.2000	2.5333	S6	S6	3.5000	4.3611	7
Data reading direction				Data reading direction			
SF : Success Factors, Sort : Descending from greatest to least Ranking: Exact hierarchy of importance							
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system							

Table 6.34 Two-Way ANOVA Analysis Results Summary for Owners and Engineers

Source	D1	D2	D3	D4	D5	D6	D7
Success Factors	YES	YES	YES	YES	YES	YES	YES
Group	YES	YES	YES	YES	NO	YES	YES
Interaction	NO	NO	NO	YES	NO	NO	NO
D1 : Lack of communication between parties D2 : Slow decision making D3 : Change orders D4 : Contractor's inadequate planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience							

An examination of the two-way ANOVA results in Table 6.35 shows that certain critical success factors were seen as having a greater influence in preventing individual critical delay factors. Respondents demonstrated different opinions about the most influential success factors to avoid delay factors, and indicated that *safety procedures (S6)* was the least influential factor on most of the delay factors.

Table 6.35 Two Way ANOVA Results for Owners and Engineers

	D1	D2	D3	D4	D5	D6	D7
	Highest						
S	$5^{(6,7)}$	$5^{(6,7)}$	$1^{(6)}$	$2^{(3,4)}$	$5^{(6)}$	$1^{(3,6)}$	$5^{(6)}$
S	$4^{(6)}$	$4^{(6)}$	$5^{(6)}$	7	$4^{(6)}$	$5^{(6)}$	$1^{(2,6)}$
S	$1^{(3,6)}$	$1^{(3,6)}$	7	5	7	$2^{(3,6)}$	7
S	7	$2^{(3,6)}$	$4^{(6)}$	6	$1^{(5)}$	$4^{(6)}$	$4^{(6)}$
S	$2^{(4,5,6)}$	7	$2^{(6)}$	$1^{(3)}$	$2^{(5)}$	7	$3^{(6)}$
S	$3^{(4,5)}$	$3^{(4,5)}$	$3^{(6)}$	$4^{(5,6,7)}$	$3^{(4,5)}$	$3^{(4,5,7)}$	$2^{(4,5)}$
S	$6^{(7)}$	6	$6^{(7)}$	$3^{(3,6)}$	$6^{(7)}$	$6^{(7)}$	$6^{(7)}$

S1: Organisational planning S2: Project manager’s goal commitment S3: Project team’s motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager’s capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system	D1 : Lack of communication between parties D2 : Slow decision making D3 : Change orders D4 : Contractor’s inadequate planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience

Success Factor Effect

Results of each seven individual 2(Group) x 7(Success Factor) two-way ANOVA tests demonstrated a significant effect for success factors (range of result: $f(6,336) = 2.274$, $p < .036$ to $f(6,329) = 5.231$, $p < .001$).

For each of the seven delay factors, respondents identified differences in the influence of the seven critical success factors on each critical delay factor.

Group Main Effect

The examination of the group main effect from Table 6.36 reveals that there are significant differences for *lack of communication between parties (D1), slow decision making (D2) change orders (D3), inadequate contractor planning (D4), subcontractor performance (D6*) and *inadequate contractor experience (D7).* Engineers evaluated the combined influence of success factors as more influential in prevention of all the delay factors except *finance and payment of completed work (D5)*, compared with owners. Detail of each delay for main effect is shown in tables 6.36a, 6.36b, 6.36c, 6.36d, 6.36e and 6.36f.

Table 6.36 Group Main effect- Owners and Engineers

DF	(I) GROUP	(J) GROUP	Mean (I – J)	Sig. (p)
D1	3.8667	3.3985	0.4682	.000
D2	3.7744	3.1765	0.5979	.000
D3	4.0357	3.1816	0.8541	.000
D4	3.6473	3.3333	0.3143	.025
D6	3.5437	2.9490	0.5947	.000
D7	4.0556	3.3529	0.7027	.000

D1 : Lack of communication between parties
D2 : Slow decision making
D3 : Change orders
D4 : Contractor's inadequate planning
D5 : Finance and payment of completed work
D6 : Subcontractor performance
D7 : Inadequate contractor experience

Table 6.36a Group Main Effect on D1 (Lack of communication)-Owner and Engineer

Delay 1						
	Owner n = 19		Engineer n = 30		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.6316	1.46099	4.0667	.82768	3.8492	5
2	3.3158	1.41628	3.7000	.87691	3.5079	4
3	3.3684	1.42246	3.3667	.92786	3.3676	1
4	3.4737	1.54087	4.3667	.99943	3.9202	7
5	3.6842	1.45498	4.7000	.59596	4,1921	2
6	2.9474	1.31122	3.1667	1.17688	3.0571	3
7	3.3684	1.34208	3.7000	.87691	3.5342	6
M	3.3985		3.8667			

SF : Success Factors, ST,D : Standard Deviation
Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)

S1: Organisational planning
S2: Project manager's goal commitment
S3: Project team's motivation and goal orientation
S4: Clarity of the project scope and work definition
S5: Project manager's capabilities and experience
S6: Safety precautions and applied procedures
S7: Use of Control system

Table 6.36b Group Main Effect on D2 (Slow decision making) - Owner and Engineer

Delay 2						
	Owner n = 17		Engineer n = 38		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	
1	3.2353	1.34766	4.1579	.91611	3.6966	5
2	3.1765	1.23669	3.9211	1.30242	3.5488	4
3	2.8824	1.26897	3.2105	1.59658	3.0465	1
4	3.2941	1.15999	4.1579	.91611	3.7260	2
5	3.9412	1.24853	4.1579	.91611	3.7260	7
6	2.7647	1.09141	3.1316	1.43642	2.9482	3
7	2.9412	1.29762	3.6842	1.42622	3.3127	6
M	3.1765		3.7744			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system						

Table 6.36c Group Main Effect on D3 (Change orders) - Owner and Engineer

Delay 3						
	Owner n =15		Engineer n= 32		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	
1	3.4000	1.35225	4.5625	.61892	3.9813	1
2	2.9333	1.27988	4.0938	1.22762	3.5136	5
3	3.1333	1.30201	3.1563	1.32249	3.1448	7
4	3.4000	1.35225	4.0625	1.10534	3.7313	4
5	3.4667	1.45733	4.3750	.79312	3.9209	2
6	2.7333	1.22280	3.5313	1.07716	3.1323	3
7	3.2000	1.32017	4.4688	.76134	3.8344	6
M	3.1810		4.0357			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system						

Table 6.36d Group Main Effect on D4 (Inadequate contractor planning) - Owner and Engineer

Delay 4 (Inadequate contractor planning)						
	Owner n = 18		Engineer n= 32		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	
1	3.6111	1.46082	3.4063	1.34066	3.5087	2
2	3.2222	1.47750	4.2188	.87009	3.7205	7
3	3.2778	1.44733	2.8125	1.22967	3.0452	5
4	3.5000	1.46528	2.8125	1.22967	3.1563	6
5	3.0000	1.49509	4.2813	.99139	3.6407	1
6	3.0000	1.49509	4.2813	1.05446	3.6407	4
7	3.7222	1.27443	3.7188	1.08462	3.7205	3
M	3.3333		3.6473			
Where SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system						

Table 6.36e Group Main Effect on D6 (Subcontractor) - Owner and Engineer

Delay 6 (Subcontractor)						
	Owner n = 14		Engineer n= 36		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.0000	1.35873	4.1667	1.10841	3.5834	1
2	3.0714	1.32806	3.8056	1.19090	3.4385	5
3	2.9286	1.26881	2.7778	1.33333	2.8532	2
4	3.2143	1.42389	3.5556	1.25230	3.3850	4
5	3.0714	1.32806	4.0278	1.15847	3.5496	7
6	2.7143	1.38278	2.7778	1.35459	2.7461	3
7	2.6429	1.27745	3.6944	1.26083	3.1687	6
M	2.9490		3.5437			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system						

Table 6.36f Group Main Effect on D7 (Inadequate contractor experience) - Owner and Engineer

Delay 7 (Inadequate contractor experience)						
	Owner n = 17		Engineer n= 36		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.5882	1.27764	4.3611	.86694	3.9747	5
2	2.9412	1.51948	3.6944	1.06421	3.3178	1
3	3.5294	1.32842	4.0278	1.08196	3.7786	7
4	3.5294	1.46277	4.1389	1.09942	3.8342	4
5	3.7647	1.25147	4.3056	.92023	4.0352	3
6	2.7059	1.35852	3.5000	1.10841	3.1030	2
7	3.4118	1.32565	4.3611	.89929	3.8865	6
M	3.3529		4.0556			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system						

Group by Success Factors (Interaction)

There was a significant Group by Success Factor interaction - as shown in Table 6.39 - in the case of *inadequate contractor planning (D4).* Engineers indicated *organisational planning (S1)* is more influential in avoiding delay factors caused by *inadequate contractor planning (D4),* whilst owners evaluated use of *control systems (S7)* as the most influential factor. Engineers indicated that *project team's motivation and goal orientation (S3)* is the least influential factor compared to the owner's preference for *safety precautions and applied procedures (S6)* when avoiding the delay factor due to *inadequate contractor planning (D4).*

Table 6.37 Interaction in D4 (Inadequate contractor planning)

Owner D4				Engineer D4			
SF	Mean	Sorting	Ranking	Ranking	Sorting	Mean	SF
1	3.6111	3.7222	S7	S1	4.2813	3.4063	1
2	3.2222	3.6111	S1	S6	4.2813	4.2188	2
3	3.2778	3.5000	S4	S2	4.2188	2.8125	3
4	3.5000	3.2778	S3	S7	3.7188	2.8125	4
5	3.0000	3.2222	S2	S5	3.4063	4.2813	5
6	3.0000	3.0000	S5	S4	2.8125	4.2813	6
7	3.7222	3.0000	S6	S3	2.8125	3.7188	7
Data reading direction				Data reading direction			
SF : Success Factors, Sort : Descending from greatest to least Ranking: Exact hierarchy of importance							
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system							

6.5.4.4 *Owner, Contractor and Engineer*

By examining these three groups as a combined group it is possible to investigate how they collectively evaluate the seven critical success factors' relative influence on each separate delay factor. The results of this investigation are shown in Table 6.38. Detailed results can be found in Appendix E10, E11 and E12.

Table 6.38 Two-Way ANOVA Analysis Results Summary for Owners, Contractors and Engineers

Source	D1	D2	D3	D4	D5	D6	D7
Success Factors	YES	YES	YES	YES	YES	YES	YES
Group	YES	YES	YES	NO	NO	YES	YES
Interaction	NO	NO	NO	YES	NO	NO	YES

Results Description

An examination of the Two-way ANOVA Table 6.39 for the combined group (owners, contractors and engineers), shows that *project manager capability (S5)* was rated the most influential success factor on all delay factors with the exception of *subcontractor performance (D6*). The combined group rated *organisational planning (S1)* as most influential in avoiding delay caused by *subcontractors (D6).*

The group is in agreement in rating *safety precaution and procedure (S6)* as the least influential factor to avoid most of the delay factors, except for *inadequate contractor planning (D4),* where the group indicated *project team's motivation and goal orientation (S3)* is the least influential factor. There are different opinions on the ranking of the rest of the success factors' impact on delay factors.

Table 6.39 Two Way ANOVA Results (Owners, Contractors and Engineers)

	D1	D2	D3	D4	D5	D6	D7
	Highest						
S	$5^{(6,7)}$	$5^{(6,7)}$	$5^{(6)}$	5	$5^{(6)}$	$1^{(3,6,7)}$	$5^{(6)}$
S	$1^{(3,6)}$	$4^{(6)}$	$1^{(6)}$	7	$4^{(5,6)}$	$5^{(6)}$	$1^{(2,3,6)}$
S	$4^{(6)}$	$1^{(3,6,7)}$	7	$1^{(3,4)}$	7	$2^{(3,6)}$	7
S	7	$2^{(3,5,6)}$	$4^{(5,6)}$	$2^{(3,4)}$	$1^{(5,6)}$	$4^{(6)}$	$4^{(6)}$
S	$2^{(4,5)}$	7	$2^{(6)}$	$4^{(5,7)}$	$2^{(5)}$	7	$3^{(5,6)}$
S	$3^{(4,5)}$	$3^{(4,5)}$	$3^{(5,6)}$	$6^{(7)}$	$3^{(4,5,7)}$	$3^{(4,5,7)}$	2
S	$6^{(7)}$	$6^{(7)}$	$6^{(7)}$	$3^{(5,6,7)}$	$6^{(7)}$	$6^{(7)}$	$6^{(7)}$

S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system	D1 : Lack of communication between parties D2 : Slow decision making D3 : Change orders D4 : Contractor's inadequate planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience

Success Factors Effect

Result for each of the seven individual 3 (Group) x 7 (Success Factor) two-way analysis of variance ANOVA tests demonstrated a significant main effect for success factors. Results of each seven individual 2(Group) x 7(Success Factor) two-way ANOVA tests demonstrated a significant effect for success factors (range of result f (6, 553) =9.533, p < .001 to f (6, 441) = 3.241, p< .005).

Group Main Effect

Examination of the group main effect in Table 6.40 shows that five of the analyses demonstrated significant effects. Details for each delay factor of the group main effect is shown in table 6.40a, 6.40b, 6.40c, 6.40d, and 6.40e. These are:

- *Lack of communication between parties (D1):* ($F(2, 44) = 1.2787$, $p < 0.001$). Compared with the contractors, engineers found the combined influence of success factors to be more influential in preventing *lack of communication between parties (D1).*
- *Slow decision making (D2):* ($F(2, 533) = 1.448$). Engineers believed that the combined influence of success factors is more influential in preventing the D2 critical delay factor.
- *Change orders (D3)*: ($F(2, 364) = 12.689$, $p < 0.001$). Compared with owners, engineers believed that the combined influences of success factors are more influential.
- *Subcontractor performance (D6):* ($F(2, 462) = 18.712$, $p < 0.001$). Compared with owners, contractors demonstrated a strong belief that the combined influence of success factors is more influential.
- *Inadequate contractor experience (D7):* ($F(2, 433) = 36.270$, $p < 0.001$). Compared with owners, engineers found the combined influence of success factors to be more influential in preventing *inadequate contractor experience (D7).*

Table 6.40 Group Main Effect (Owner, Contractor & Engineer)

DF	(I) GROUP	(J) GROUP	Mean (I – J)	Sig. (p)
D1	Engineer	Contractor	3.8667 -3.2101 = 0.6566	.000
D2	Engineer	Owner	3.7744 – 3.1765 = 0.5979	.000
D3	Engineer	Owner	4.0357 – 3.1810 = 0.8547	.000
D6	Contractor	Owner	3.9098 – 2.9490 = 1.049	.000
D7	Engineer	Owner	4.0556 – 3.3529 = 0.7027	.000

D1 : Lack of communication between parties
D2 : Slow decision making
D3 : Change orders
D4 : Contractor’s inadequate planning
D5 : Finance and payment of completed work
D6 : Subcontractor performance
D7 : Inadequate contractor experience

Table 6.40a Group Main Effect on D1(Lack of communication)

Delay 1								
	Owner n = 19		Contractor n= 17		Engineer n = 30		Marginal mean owner + contractor)/3	Sorting Highest to Lowest
SF	Mean	St.D	Mean	St.D	Mean	St.D	M	SF
1	3.6316	1.46099	3.5882	1.50245	4.0667	.82768	3.7622	5
2	3.3158	1.41628	3.0588	1.34493	3.7000	.87691	3.3582	1
3	3.3684	1.42246	2.5882	1.32565	3.3667	.92786	3.1078	4
4	3.4737	1.54087	3.4118	1.46026	4.3667	.99943	3.7507	7
5	3.6842	1.45498	3.8235	1.46779	4.7000	.59596	4.0692	2
6	2.9474	1.31122	2.6471	1.53872	3.1667	1.17688	2.9204	3
7	3.3684	1.34208	3.3529	1.32009	3.7000	.87691	3.4738	6
M	3.3985		3.2101		3.8667			
SF : Success Factors, ST,D : Standard Deviation, Marginal or (M0 : accumulative mean by raw , (SF's effect) or column (group effect)								
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system								

Table 6.40b Group Main Effect on D2 (Slow decision making)

Delay 2								
	Owner n = 17		Contractor n= 27		Engineer n =38		Marginal mean owner + contractor)/3	Sorting Highest to Lowest
SF	Mean	St.D	Mean	St.D	Mean	St.D	M	
1	3.2353	1.34766	3.9259	1.41220	4.1579	.91611	3.7730	5
2	3.1765	1.23669	3.4815	1.18874	3.9211	1.30242	3.5264	4
3	2.8824	1.26897	3.2222	.93370	3.2105	1.59658	3.1050	1
4	3.2941	1.15999	3.8519	1.37851	4.1579	.91611	3.9531	2
5	3.9412	1.24853	4.4074	.88835	4.1579	.91611	4.1688	7
6	2.7647	1.09141	2.7778	.80064	3.1316	1.43642	2.8914	3
7	2.9412	1.29762	3.6296	1.07946	3.6842	1.42622	3.4183	6
M	3.1765		3.6138		3.7744			
SF : Success Factors, ST,D : Standard Deviation, Marginal or (M0 : accumulative mean by raw , (SF's effect) or column (group effect)								
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system								

Table 6.40c Group Main Effect on D3 (Change orders)

Delay 3								
	Owner n =15		Contractor n= 20		Engineer n =32		Marginal mean owner + contractor)/3	Sorting Highest to Lowest
SF	Mean	St.D	Mean	St.D	Mean	St.D	M	SF
1	3.4000	1.35225	4.2000	1.00525	4.5625	.61892	4.0542	5
2	2.9333	1.27988	4.0000	1.29777	4.0938	1.22762	3.6757	1
3	3.1333	1.30201	3.7500	1.16416	3.1563	1.32249	3.3465	7
4	3.4000	1.35225	3.7500	1.16416	4.0625	1.10534	3.7375	4
5	3.4667	1.45733	4.3500	.98809	4.3750	.79312	4.0639	2
6	2.7333	1.22280	3.0000	1.02598	3.5313	1.07716	3.0882	3
7	3.2000	1.32017	4.0000	1.21395	4.4688	.76134	3.8896	6
M	3.1810		3.8643		4.0357			
SF : Success Factors, ST,D : Standard Deviation, Marginal or (M0 : accumulative mean by raw, (SF's effect) or column (group effect)								
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system								

Table 6.40d Group Main Effect on D6 (Subcontractors)

Delay 6								
	Owner n = 14		Contractor n=		Engineer n =36		Marginal mean owner + contractor)/ 3	Sorting Highes t to Lowest
SF	Mean	St.D	Mean	St.D	Mean	St.D	M	SF
1	3.0000	1.35873	4.4211	1.01739	4.1667	1.10841	3.8626	1
2	3.0714	1.32806	4.1579	.89834	3.8056	1.19090	3.6783	5
3	2.9286	1.26881	3.2632	.87191	2.7778	1.33333	2.9899	2
4	3.2143	1.42389	4.1579	.89834	3.5556	1.25230	3.6426	4
5	3.0714	1.32806	4.3684	.76089	4.0278	1.15847	3.8225	7
6	2.7143	1.38278	3.0000	1.05409	2.7778	1.35459	2.8307	3
7	2.6429	1.27745	4.0000	.88192	3.6944	1.26083	3.4458	6
M	2.9490		3.9098		3.5437			
SF : Success Factors, ST,D : Standard Deviation, Marginal or (M0 : accumulative mean by raw, (SF's effect) or column (group effect)								
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system								

Table 6.40e Group Main Effect on D7 (Inadequate contractor experience)

Delay 7								
	Owner n = 17		Contractor n= 15		Engineer n = 36		Marginal mean owner + contractor)/3	Sorting Highest to Lowest
SF	Mean	St.D	Mean	St.D	Mean	St.D	M	SF
1	3.5882	1.27764	4.6667	.61721	4.3611	.86694	4.2053	5
2	2.9412	1.51948	3.8000	1.37321	3.6944	1.06421	3.4785	1
3	3.5294	1.32842	3.2667	1.38701	4.0278	1.08196	3.6080	7
4	3.5294	1.46277	3.8667	1.35576	4.1389	1.09942	3.7784	4
5	3.7647	1.25147	4.6667	.89974	4.3056	.92023	4.2457	3
6	2.7059	1.35852	2.5333	.99043	3.5000	1.10841	2.9131	2
7	3.4118	1.32565	4.2000	.94112	4.3611	.89929	3.9910	6
M	3.3529		3.8571		4.0556			
SF : Success Factors, ST,D : Standard Deviation, Marginal or (M0 : accumulative mean by raw, (SF's effect) or column (group effect)								
S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system								

Interaction (Owners, Contractors and Engineers)

There are interaction results for the delay factors *inadequate contractor planning (D4)* and *inadequate contractor experience (D7).* Tables 6.41 and 6.41a show the analysis of these results. In the case of *inadequate contractor planning (D4)* there was a significant group by success factor interaction (F (12, 44) = 4.909, p < 0.001). An examination of post-hoc comparisons suggests that the relative ranking of influence of owners, contractors and engineers differs. Contractors and engineers believed *project manager goal commitment (S2)* to be of a higher influence than did owners. Compared with engineers, owners and contractors evaluated *safety precaution and procedure* as the least influential factor.

Inadequate contractor experience (D7) showed a significant group by success factor interaction (D7) F (2, 433) = 1.9888, p < 0.25). Compared with engineers, owners and contractors held a stronger belief that *project* *manager goal commitment (S2*) is more influential on the critical delay. The three groups believed the *subcontractor problem (S6)* to be the least influential factor to the critical delay factor *inadequate contractor experience (D7).*

Table 6.41 Interaction (Owners, Contractors and Engineers)-D4 (Inadequate contractor planning)

Owners D4				Contractors D4				Engineers D4			
SF	Mean	Sort	Rnk	SF	Mean	Sort	Rnk	SF	Mean	Sort	Rnk
1	3.6111	3.7222	S7	1	4.1256	4.2500	S5	1	3.4063	4.2813	S5
2	3.2222	3.6111	S1	2	3.0625	4.1250	S1	2	4.2188	4.2016	S6
3	3.2778	3.5000	S5	3	3.1250	3.8125	S7	3	2.8125	4.2188	S2
4	3.5000	3.2777	S3	4	3.6875	3.6875	S4	4	2.8125	3.7188	S7
5	3.0000	3.2222	S2	5	4.2500	3.1250	S3	5	4.2813	3.4063	S1
6	3.0000	3.0000	S5	6	2.6250	3.0625	S2	6	4.2813	2.8125	S4
7	3.7222	3.0000	S6	7	3.8125	2.6250	S6	7	3.7188	2.8125	S3

S1: Organisational planning
S2: Project manager's goal commitment
S3: Project team's motivation and goal orientation
S4: Clarity of the project scope and work definition
S5: Project manager's capabilities and experience
S6: Safety precautions and applied procedures
S7: Use of Control system

Table 6.41a Interaction (Owners, Contractors and Engineers)-D7 (Inadequate contractor experience)

Owners D7				Contractors D7				Engineers D7			
SF	Mean	Sort	Rnk	SF	Mean	Sort	Rnk	SF	Mean	Sort	Rnk
1	3.5882	3.7647	S5	1	4.6667	4.6667	S5	1	4.3611	4.3611	S1
2	2.9412	3.5882	S1	2	3.8000	4.6667	S1	2	3.6944	4.3611	S7
3	3.5294	3.5294	S3	3	3.2667	4.2000	S7	3	4.0278	4.3056	S5
4	3.5294	3.5294	S4	4	3.8667	3.8667	S4	4	4.1389	4.1309	S4
5	3.7647	3.4118	S7	5	4.6667	3.8000	S2	5	4.3056	4.0278	S3
6	2.7059	2.9412	S2	6	2.5333	3.2667	S3	6	3.5000	3.6944	S2
7	3.4118	2.7059	S6	7	4.2000	2.5330	S6	7	4.3611	3.5000	S6

S1: Organisational planning
S2: Project manager's goal commitment
S3: Project team's motivation and goal orientation
S4: Clarity of the project scope and work definition
S5: Project manager's capabilities and experience
S6: Safety precautions and applied procedures
S7: Use of Control system

6.5.4.5. Conclusion

Two way ANOVA results showed there are similarities and differences between the influence of critical success factors on critical delay factors. Owners and contractors demonstrated differences in the influence of critical success factors and critical delay factors, except for *lack of communication between parties (D1).* The group also believed the combined group of success factors (group main effect) has more influence on individual delay factors, except for *lack of communication between parties (D1)* and *inadequate contractor planning (D4).* The group showed significant differences in the ranking of success factors (interaction) for *slow decision making (D2), inadequate contractor planning (D4)* and *inadequate contractor experience (D7).* However the group agreed that the *project manager's capabilities and experience (S5)* and *organisational planning (S1)* are the most important success factors, whilst *safety precautions and applied procedures (S6)* are the least important.

Contractors and engineers strongly agreed that there are differences in the influence of critical success factors and critical delay factors. The group indicated the combined success factors (group main effect) has more influence on individual delay factors, except for *slow decision making (D2), inadequate contractor planning (D4), finance and payment of completed work (D5)* and *inadequate contractor experience (D7).* The group showed significant differences in the ranking of success factors (interaction) for *inadequate contractor planning (D4)* and *inadequate contractor experience (D7).* The group agreed that the *project manager's capabilities and experience (S5)* is the most important success factor and *safety precaution and applied procedure (S6)* the least important.

Owners and engineers showed strong agreement on differences in the influence of critical success factors and critical delay factors. The group also strongly agreed that the combined success factors (group main effect) helps to avoid the critical delay factors except for *finance and payment of completed work (D5).* The group showed one significant ranking (interaction) on delay factors caused by *inadequate contractor planning (D4)* and *inadequate contractor experience (D7).*

The owners, engineers and contractors strongly agreed on the differences in the influence of critical success factors and critical delay factors. The group agreed that the combined group of success factors (main effect) has more influence on delay factors except for *inadequate contractor planning (D4) and finance and payment of completed work (D5).* The group showed significant ranking (interaction) on critical success factors for delay caused by *inadequate contractor planning (D4) and inadequate contractor experience (D7).* However the group agreed the most influential success factor for delay factor is the *project manager's capabilities and experience (S5),* and the least influential is *safety precautions and applied procedure (S6).*

To conclude, the results show that survey respondents (owners, contractors, and engineers) were in agreement regarding which critical success factors were most influential in avoiding or preventing critical delay factors. The results indicate strong agreement on the differences in the influence of critical success factors and critical delay factors (success factors). The group also agreed that the combined group of success factors (main effect) has more influence on the delay factors. The group has shown some differences in the ranking of the success factors on the delay factors, but the group consistently ranked the most influential success factor to avoid the delay factors is *project manager capabilities and experience (S5),* and the least influential is *safety precautions and applied procedures (S6).*

6.5.5 Overall Ranking

The respondents (owners, contractors, and engineers) were tested on the importance of the success factors on avoiding delay factors individually and collectively. This study resulted in the overall ranking of critical success factors for construction processes, which motivated the current study to fill the gap in the research literature. The method for evaluating the relative importance of the success factors across all the delay factors for each group was developed, as follows:

Success factor importance = ∑ (f) x (r)
Where r = rank from 1 to 7 and f = frequency that a specific rank was assigned to a success factor across the 7 delay factors.

The first step was to rank the means for the seven success factors for each delay factor. The success factor with the lowest mean (rating of influence on the delay factor) would be assigned the rank of 1; the success factor that had the highest mean (rating of influence on the delay factor) would be assigned the rank of 7. Next, the importance index was computed as the sum of the products of the frequency (across the 7 delay factors); each success factor received a given rank times the numeric value of the rank. Since there are 7 delay factors, the frequencies must sum to 7.

Table 6.42 shows the result of a one-way ANOVA for owners. Success factor one received a rank of 6 for four delay factors, a rank of 5 for two delay factors and a rank of 4 for one delay factor. The total is the total product of the rank and the frequency (detailed results of success factor importance can be found in Appendix F).

Table 6.42 One Way ANOVA - summary result for Owners

	D1	D2	D3	D4	D5	D6	D7	SF	SF Importance	Sorting
S	5	5	5	7	5	4	5	S1	42	S7
S	1	4	1	1	4	5	1	S2	45	S2
S	4	1	4	4	1	2	4	S3	40	S1
S	7	2	7	3	2	1	3	S4	37	S6
S	3	7	3	2	7	3	7	S5	40	S3
S	2	3	2	5	3	6	2	S6	42	S5
S	6	6	6	6	6	7	6	S7	48	S4

S1: Organisational planning S2: Project manager’s goal commitment S3: Project team’s motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager’s capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system	D1 : Lack of communication between parties D2 : Slow decision making D3 : Change orders D4 : Inadequate contractor planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience

Table 6.43 Success factor one in owner case

								Total
Rank	1	2	3	4	5	6	7	
Freq				1	2	4		
Product				4	10	24		38

Groups Overall Perceived Success Factors Importance

The overall importance for each tested group and the study's overall success factors are listed in table 6.44 below. Detailed results can be found in Appendix F1 to F9. The highest ranking of the study's success factors for all the delay factors is the *project manager's capability and experience (S5),* followed by *organisational planning (S1), clarity of project scope and definition (S4), use of control systems (S7), project manager's goal commitment (S2), project team motivation and goal orientation (S3)* and *safety precautions and applied procedures (S6).*

Table 6.44 Group Overall Perceived Success Factors Importance

	O	C	E	O + C	O + E	C + E	O + C + E	SF	SF Importance	Sorting
S	5	5	5	5	5	5	5	S1	41	S5
S	4	1	1	1	1	1	1	S2	22	S1
S	1	4	7	4	4	7	4	S3	14	S4
S	2	3	4	7	7	4	7	S4	33	S7
S	7	7	2	2	2	2	2	S5	49	S2
S	3	2	3	3	3	3	3	S6	7	S3
S	6	6	6	6	6	6	6	S7	30	S6

Where
O : Owners, C: Contractors, E: Engineers (One way ANOVA)
O+ C: Owners and Contractors – combined (two way ANOVA)
O + E : Owners and Engineers – combined (two way ANOVA)
C + E : Contractors and Engineers –combined (two way ANOVA)
O + C + E : Owner, Contractor and Engineer (two way ANOVA)

S1: Organisational planning S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of Control system	D1 : Lack of communication between parties D2 : Slow decision making D3 : Change orders D4 : Inadequate contractor planning D5 : Finance and payment of completed work D6 : Subcontractor performance D7 : Inadequate contractor experience

The priority list of success factors resulting from this study is not the same as the priorities noted in the literature. *Project manager's capability and experience (S5*) was ranked 5th in the literature and *organisational planning (S1)* was the most important factor*. Clarity of project scope and definition (S3*) was ranked 4th in the literature*. Use of control systems (S7)* which is the least important success factor in the literature, was ranked 4th in this study.

There are a number of possible explanations for this outcome. This study addressed only the seven success factors, which may have affected their priority. Secondly, the target project was public, and was evaluated by different project participants, compared with the study by Ashley et al (1987) where data was obtained from eight companies, each contributing one average and one outstanding project, totalling 16 projects, 82% of which were private.

Another reason for this outcome could be that the ranking of the success factors in this study were done for projects during their construction, whilst Ashley's study included projects in different stages of their lifecycle. This study was also restricted to the Brunei building construction industry, with its different environmental, political and cultural issues. Finally the immature nature of Brunei's construction industry and the capabilities of personnel in developing countries may also account for these differences in outcomes.

CHAPTER 7

A DELPHI METHODOLOGY: STAGE 3 - RANKING THE CRITICAL SUCCESS FACTORS

This thesis examines how the building construction industry in the developing country of Brunei can employ critical success factors to avoid delay factors by identifying and ranking the most significant components of critical success factors, and applying these to avoid the delay factors identified from the survey of Brunei building construction projects.

Further to the investigation of methodologies in chapter 4, this chapter reassesses the consensus-forming Delphi method. While the previous chapter reviewed the critical success factors for construction processes, this chapter utilises the Delphi method to rank the critical success factors for the delay factors in building construction in Brunei.

The Delphi method was selected as it provides the researcher with a flexible and adaptable tool to gather and analyse data. This chapter describes the Delphi method using an expert panel to rank the most important critical success factors for Brunei building construction processes. The critical success factors and critical delay factors identified in chapters 5 and chapter 6 are shown in Table (7.1).

Table (7.1) Success factors and Delay factors

Delay Factors	Success Factors
Lack of communication between parties	Project manager's capability and experience
Slow decision making	Organisational planning
Change orders	Clarity of project scope and definition
Inadequate contractor planning	Use of control systems
Finance and payment of completed work	Project manager's goal commitment
Subcontractor performance	Project team's motivation and goal orientation
Inadequate contractor experience	Safety precautions and applied procedures

7.1 THE DELPHI METHODOLOGY: Ranking the critical success factors for Brunei building construction projects

The Delphi questionnaire was initially discussed and piloted with experienced project managers and a number of qualified engineers. The piloting was done to test whether the questionnaire was intelligible, unambiguous and easy for the selected panel to understand and respond to.

A panel of experts was identified to perform the Delphi method. The personal characteristics and professional experience of the panels and the relationship between the panels' background, topic to be investigated, the concepts identified, and the site of the study are important considerations, particularly for the Delphi questionnaire. The expert panel are representatives of government, business, educators, private construction firms, and local organizations. This was done to assure validity of the results from reasonable distribution of expert opinion and expert judgement on the industry.

The experts considered for this research are from several professions such as:

- Owner organisations
- Contracting organisations
- Consultants
- Engineers or designers

All potential expert group members were contacted personally to determine their willingness to participate in the research, and to gauge whether they met the following criteria for selection. The experts met the criteria as follows:

- Over ten years of contract management experience in building construction
- Had acted in the role of owners', contractors' and engineers' representative
- Willing to participate in the entire process
- Willing to share ideas.

Initially, the two-round Delphi survey was conducted targeting a group of 28 experts, who were selected to represent different viewpoints in the range between the experts and authorities responsible for strategic decision-making in building construction in Brunei. Before the respondents answered the Delphi questionnaire, they were presented with a letter of instruction (Appendix A1). This letter contained a description of the main objective of the research, the methodology used and the research question to be answered.

The Delphi survey was prepared using two rounds of questionnaires. In the questionnaire for the first round, the respondents were asked to consider seven critical success factors to avoid delay factors in Brunei building construction. An explanatory note was appended with each critical factor to give a quick definition and reason for the critical success factor selections.

Based on their experience, respondents were asked to rank these success factors in terms of urgency and importance of impact on the process of avoiding delay factors. Participants were permitted to add any additional factor to the list they felt should be included. The questionnaires were initially in English. Definitions were attached and any ambiguities about the ranking were explained personally or by other available communication such as emails and telephone.

In response to the importance of the success factors, respondents were asked to think of the local capabilities, potential, and the associated barriers and deficits. Respondents were then asked to answer:

> ***What are the most needed success factors for avoiding delay factors in the Brunei Building Construction Industry?***

The respondents were asked to rank each success factors based on a numerical order from 1 to 7, with 1 indicating most important or most needed strategy and 7 indicating the least needed or less critical strategy, according to its importance in the short to medium future for better building construction. Additional information was considered to identify each respondent with respect to position or title, place of work, years of experience and work achievement.

For round one, the questionnaire was sent via email to the correspondents' addresses at the same time on the same day. The questionnaire was also designed to allow additional suggestions. These additional suggestions (if any) were not to be scored until round two. When the respondents returned the questionnaire from the first round, the results were analysed, tabulated and returned to the respondents for their further consideration, along with the questionnaire of the second round (Appendix I).

Twenty experts responded to the first round. Respondents were experts from owner's, contractor's and engineer's representatives:

- Ministry Of Development
- University of Brunei
- Consulting firms (local and international experience)
- Construction and contracting firms (local and international experience)
- Public Works Department.

After completing the first round with a reasonable number of participants having responded, the group received the questionnaire adjusted for round two. In the second round questionnaire, each participant was asked to review his/her original responses about the ranking of the critical success factors, and to compare them with those of the entire group, before making their final decision.

The purpose of the second round was to create a consensus among experts and confirm the key issues identified in the first round. In addition, the second round increased the opportunity to get a deeper perspective on the evaluation process. The group members were asked if they wished to change or confirm their responses in view of the new information. After the respondents had completed these questionnaires, the material was collected and processed. Some panel members did make changes in their ranking from the first round questionnaire.

After processing the responses from round two, it was determined that additional rounds of questioning would not produce significant changes of opinion and therefore additional questionnaires were deemed unnecessary. Sufficient time required to collect information and reach a consensus in many cases is up to three iterations (Worthen & Sandlers, 1987: Brooks, 1979). Theoretically the process can be continuously iterated until consensus is achieved at the desired level. As the average and median ranking generally remained the same, we can assume that a reasonable level of consensus has been reached; therefore it was decided that a two-round Delphi process was satisfactory on this occasion.

Ultimately, only 15 experts were used. The elimination of experts was based on two criteria. Firstly, a number of experts did not respond to the second round of the survey. Secondly, respondents consistently ranked success factors equally, indicating the results were stable. The 15 experts used were as follows:

- Ministry of Development (5)
- University of Brunei (2)
- Consulting firms (3)
- Construction and contracting firms (2)
- Public Works Department (3)

7.2 TABULATION OF THE FIRST ROUND RESPONSES

The first round responses of the Delphi survey were tabulated and analysed using a distribution ranking table to annotate the average ranking, median ranking and the order of importance of each strategy, as indicated in Table 7.2. Experts were denoted by alphabetical letters.

Table7.2 Delphi First round

	Ranking by participants															Avg Mean	Median rnk	Impt order
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O			
S1	3	3	3	2	3	2	1	3	1	2	5	1	2	3	2	2.4	2	3
S2	5	4	5	5	5	4	6	5	2	5	2	3	5	5	5	4.4	5	5
S3	6	6	6	6	6	6	5	4	6	6	3	6	6	6	6	5.6	6	6
S4	2	1	2	3	2	1	4	2	4	4	1	2	3	2	3	2.4	2	2
S5	1	5	1	1	1	3	2	1	3	1	4	4	1	1	1	2.0	1	1
S6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	7	7
S7	4	2	4	4	4	5	3	6	5	3	6	5	4	4	4	4.2	4	4

S1 –Organisational Planning
S2 – Project Manager's Goal Commitment
S3 – Project Team's motivation and Goal Orientation
S4 – Clarity of Project Scope and Work Definition
S5 – Project Manager's Capabilities and Experience
S6 – Safety Precautions and Applied Procedures
S7 - Use of Control System

7.3 TABULATION AND RANKING OF RESPONSES FROM ROUND TWO

The responses from the strategy ranking of importance from two rounds of the Delphi surveys were tabulated, averaged and used to validate each strategy ranking of importance. The final ranking for the most needed success factors for the building construction industry are represented in Table 7.3.

Table7.3 Delphi Second Round

	Ranking to participants															Avg Mean	Median rnk	Impt order
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O			
S1	2	4	3	2	2	3	1	3	1	2	5	1	3	3	3	2.5	3	3
S2	5	3	5	4	5	5	6	5	3	5	2	3	6	5	5	4.5	5	5
S3	6	6	6	6	6	6	5	6	6	6	3	6	5	6	6	5.7	6	6
S4	3	1	2	1	3	2	4	2	2	4	1	2	2	2	2	2.2	2	2
S5	1	5	1	3	1	1	2	1	4	1	4	4	1	1	1	2.1	1	1
S6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	7	7
S7	4	2	4	5	4	4	3	4	5	3	6	5	4	4	4	4.1	4	4
S1 – Organisational Planning S2 – Project Manager’s Goal Commitment S3 – Project Team’s motivation and Goal Orientation S4 – Clarity of Project Scope and Work Definition S5 – Project Manager’s Capabilities and Experience S6 – Safety Precautions and Applied Procedures S7 - Use of Control System																		

7.4 CONCLUSION

The ranking from the expert panel identified that the most important critical success factors for Brunei’s building construction are:

1. *Project Manager Capabilities*
2. *Clarity of project scope*
3. *Planning effort*
4. *Use of control system*
5. *Project manager’s goal commitment.*
6. *Project team motivation and goal orientation*
7. *Safety precaution and applied procedures*

After reviewing the literature on the success factors in the previous sections, several success criteria relevant to the above critical success factors for construction processes are identified and listed as follows. Future research is suggested to investigate in detail the relevance of these criteria.

1. Project Manager Capabilities

The Project Manager is the key person on the project. Their skills need to be multi-dimensional, which includes interpersonal, technical and administrative. The 10 most important skills and competencies of a Project Manager are:

- People skills
- Leadership
- Listening
- Integrity, ethical behaviour
- Strong at building trust
- Verbal communication
- Strong at building teams
- Conflict resolution, conflict management
- Critical thinking, problem solving
- Understanding; balances priorities

The most important element is that the project manager must clearly understand the role of a project leader. They should understand the extent that they need to be involved, how to define their authority and the amount of control they should exercise over personnel. The project manager must have an impressive personality so that team players, associates and peers look up to them and respond to their requests. The project manager should have leadership skills and be competent and managerially skilful. The project manager should have the ability to persuade other group members to their view. They should also be able to resolve conflict between the parties.

Project managers should be responsible for organising, selecting and defining the responsibilities of the project team. The project manager should identify interfaces between the activities of the functional departments, subcontractors, and other project contributors. They are also responsible for monitoring progress, identifying problems, communicating the status of interfaces to contributors, and initiating and co-ordinating corrective action. The project manager should motivate the project team to perform their duties, and also convince the project team to co-operate with each other. The project manager in a construction environment must posses good technical knowledge and experience, since most projects are highly technical.

2. Clarity of Project Scope

This critical success factor requires that the end-result of the project is stated clearly, with full consultation with the related parties. Although each party might have different specific goals in mind for the project, they must spell out their goals. It is crucial for participants to state the communicated and defined goal to all parties, and to clarify time and cost objectives. It is important to present a clear design brief with minimal subsequent changes. A brief must be exact and owned by the client at the highest (strategic) level within the client and project organisations.

3. Planning Effort

The plan, or schedule, should be prepared as early as possible. The plan should be updated, with as much detail as possible, including during the design process and throughout its phases. The detail required includes individual action for project implementation, the responsible party for each action (if known), and the technical standard required. The plan should be realistic, and clearly state the appropriate workload for the project team. The plan must be updated regularly in order to keep pace with the project's development. The team should be prepared to re-plan the job schedule to accommodate frequent changes on dynamic projects. The team should incorporate detailed planning guidelines for termination.

4. Use of Control systems

Schedule control requires that the project manager and superintendents jointly agree on intermediate milestones and build the detailed schedule around these. Successful project teams celebrate these milestones with parties, aiming at breaking the monotony of a long schedule into easily managed portions. Costs' control – focus on tracking the money spent – is essential, and requires detailed actual costs. One of the best monitoring aids is a plot of plan versus actual costs on a cash-flow curve, e.g. earned – value analysis system. Quality control, which focuses on ensuring the project reaches the agreed and designed level of quality, means the project must be closely scrutinised during its entire process. The methods for performing control include regular meetings and day-to- day reports etc.

5. Project Manager's goal commitment

The role of project manager includes responsibilities such as planning, scheduling, coordinating and working with people and project teams to achieve project goals. A project manager's goal commitment focuses on long term goals and big picture objectives, while inspiring people to reach those goals. A manager deals with the day to day details of meeting specific goals.

6. Project team motivation and goal orientation

All participants must understand and be dedicated and strongly committed to achieving, maintaining and fulfilling project goals. All participants must be committed to the concept of project planning and control and must be able to put the concept into practice. They must understand the project management process, its purpose and values, and be committed to following the steps and necessary procedures Participants should possess adequate capability, including skill and experience. It is essential that appropriate interpersonal skills are encouraged, and that a good working relationship between client, project team members and stakeholders is maintained.

7. Safety Precaution and applied procedures

This criterion ensures there is the consideration and application of legislative health and safety measures.

CHAPTER 8

RESEARCH CONCLUSION

The objective of this research is to identify the critical success factors and critical delay factors which impact on the construction processes in Brunei's building construction projects. This has been pursued through the examination of the relationships between the critical success factors identified in the literature, and the delay factors identified in the construction process. Seven critical success factors and delay factors were chosen for further analysis, to determine which of the critical success factors had the most influence in avoiding the critical delay factors, thereby addressing a gap in current research, and providing construction managers with information that could lead to more successful project delivery. Finally, seven of the most influential critical success factors were ranked by a panel of experts. These were identified as the most necessary critical success factors to take into account when considering how to improve project performance in Brunei's construction industry.

8.1 SUMMARY OF DATA COLLECTIONS

8.1.1. Critical Delay factors In Brunei Building Construction Projects

The research investigated the causes of delays in construction processes confronting Brunei's building construction projects. A Relative Importance Index was used to determine the relative importance of various causes of delay. A Spearman's Rank correlation test showed positive agreement between the respondents' views about the causes of delays in Brunei's building construction projects. Based on the overall relative importance index of the respondents (owner, contractor and engineer), the seven most important causes of delay which contribute to the failure of building construction projects are:

1. *Lack of communication between parties*
2. *Slow decision making*
3. *Change orders*
4. *Inadequate contractor planning*
5. *Finance and payment of completed work*
6. *Subcontractor performance*
7. *Inadequate contractor experience*.

8.1.2 Relationship between Critical Success and Delay Factors (Pearson Correlation)

The critical success factors identified from the literature and delay factors evaluated by owners, contractors and engineers were examined using Pearson's correlation coefficient to measure the strength and direction of the relationship between these factors for projects generally. The measure showed that the owners' responses demonstrated a significant correlation between all seven critical success and critical delay factors. The results of the Pearson correlation are as follows:

- Owners show strong correlations between the critical delay factors and the critical success factors.
- Contractors show strong correlation between the critical delay factors except for delays cause by *subcontractors (D6).*
- Engineers' responses showed a very strong correlation between all the critical success factors and the critical delay factors.

The findings demonstrate a strong relationship between the critical success factors and delay factors identified in the research. It can be concluded that there is a strong correlation between success factors and delay factors for owners, contractors and engineers. The strong correlations show that owners, engineers and contractors believe that there should be relationships between the critical success factors and delay factors, and their results reflect that. The results further show that owners and engineers strongly agree that there is a significant correlation between all the critical success factors and all the delay factors. Contractors disagree that any of the critical factors will help to reduce delay factors caused by *subcontractors (D6) and inadequate contractor experience (D7).*

8.1.3 Perceptions and influence of success factors on each delay factor (t-tests for Owners, Contractors and Engineers' Responses)

T-tests were undertaken to compare the perceptions of critical success factors and critical delay factors of three groups - owners and contractors; owners and engineers; and contractors and engineers - by comparing their means and the influence of success factors on each delay factor. The t-test result primarily shows agreement - with some differences - in how owners, contractors and engineers evaluated the relations between the critical success factors, critical delay factors and the influence of critical success factors on avoiding each critical delay factor.

The results of the tests showed strong agreement between owners, contractors and engineers on their evaluation of the perceptions of critical success factors and delay factors. However some differences were seen in their evaluations of *project manager's goal commitment (S2), clarity of project scopes (S4)* and *safety precaution (S6),* explained by the fact that contractors and owners need a project manager who has full responsibility for the project to have clarity of project scope, effective communication, safety precautions and commitment to the project's goals, when implementing the project. Differences were obvious in perceptions about delay factors *inadequate contractor planning (D4), inadequate contractor experience and lack of communication (D1).* This could be because contractors and engineers are blaming the contract award process, where most of the projects are given to the lowest bidder.

Results showed that contractors and engineers agreed with each other more than any other group. Their agreement may be explained by the level of involvement in the project, with both parties more involved than owners.

8.1.4 Ranking of Critical Success Factors Influence on Critical Delay Factors (One and Two way ANOVA)

One Way ANOVA - Individual

Investigations of the influence of critical success factors on avoiding or preventing delay factors suggested that the test groups (owners, contractors, and engineers) would not be in agreement about which critical success factors were most influential in avoiding or preventing critical delay factors. This proved to be true when the results were examined separately and collectively. A one-way ANOVA was used to determine individual perceptions of the seven critical success factors' relative influence on each critical delay factor. Post-hoc examination was undertaken to determine which success factors were most significant in avoiding the same delay factors.

The differences in the least influential factor were examined from the perspectives of owners, contractors and engineers. One-Way ANOVA results identified significant differences for delay factors *change orders (D3), inadequate contractor planning (D4), and subcontractor performance (D6).* Owners believed *safety precautions (S6)* to be the least influential factor for *change orders (D3) and inadequate contractor planning (D4), and use of control system (S7)* for delay factor *subcontractor (D6).* Engineers believed *project's team motivation (S3) is the least influential factor for delay factors change orders (D3,* and that *clarity of project scope (S4)* for *inadequate contractor planning (D4) and safety precaution (S6)* was least influential for delay caused by *subcontractors (D6).* Contractors strongly believed that *safety precaution (S6*) is the least influential success factor for all the delay factors.

Generally all three groups were in agreement regarding the most influential success factors and least influential success factors at avoiding delay factors, with minor agreement in the middle range. The differences of opinion may be due to owners' tendency to view problems as created from the top down. Engineers show more consideration for the influence of the success factor *safety precaution (S6)* on the delay factors, which may be because engineers take safety precautions more seriously compared to owners and contractors, being concerned about the potential delays caused by safety mishaps. Additionally, the nature of their work causes them to be concerned with safety.

Results of the ranking of the influence of success factors by contractors and engineers as a group showed a more significant relationship between these two groups when compared with owners. This is also demonstrated in the contractor's and engineers' Post Hoc results and t-tests. This may be because contractors and engineers are closer to the project process environment, and therefore possess a clearer knowledge of the field of construction process than do owners.

Two Way ANOVA – combined group

A two–way ANOVA test was conducted in order to compare the responses of all four groups i.e. owners and contractors; owners and engineers; contractors and engineers; owners, contractors and engineers, and to identify their perceptions of the relative influence of the seven critical success factors on each individual critical delay factor. Two way ANOVA results showed there are similarities and differences in the perceptions of these groups about the influence of critical success factors on critical delay factors.

To conclude, the two way ANOVA results show that survey respondents (owners, contractors and engineers) were in agreement regarding which critical success factors were most influential in avoiding or preventing critical delay factors. The results indicated strong agreement in the influence of critical success factors and critical delay factors (success factors). The group also agreed that the combined group of success factors (main effect) has more influence on the delay factors. The groups have shown some differences in the ranking of the success factors on the delay factors but they consistently ranked the most influential success factor to avoid the delay factors is *project manager capabilities and experience (S5)* and the least influential is *safety precautions and applied procedures(S6).*

8.1.5. Overall Importance of Success Factors (Importance Index)

Groups' Overall Perceived Success Factors Importance

The overall importance for each tested group, and the study's overall success factors were evaluated. The groups' overall importance of success factors on the delay factors are:

1. *Project manager's capability and experience (S5),*
2. *Organisational planning (S1),*
3. *Clarity of project scope and definition (S4),*
4. *Use of control systems (S7),*
5. *Project manager's goal commitment (S2),*
6. *Project team motivation and goal orientation (S3) and*
7. *Safety precautions and applied procedure (S6)*

The priority given to success factors in this study is not the same as the priorities in the literature (Ashley et al, 1987)*. Project manager's capability and experience (S5)* was ranked 5th in the literature and *organisational planning (S1)* was the most important factor. *Clarity of project scope (S4)* was ranked 4th in the literature. *Use of control system (S7)* which is the least influential success factor in the literature was ranked 4th in this study. There are a number of possible explanations for this outcome. First, this study addressed only the seven success factors, which may have affected their priority. Second, the target project was public, and was evaluated by different project participants, compared with the study by Ashley et al (1987) where data was obtained from eight companies, each contributing one average and one outstanding project, totalling 16 projects, 82% of which were private.

Another reason could be due to the fact that the ranking of the success factors in this study was done on projects during construction, whilst Ashley's study included projects in different stages of lifecycle. As this study was also restricted to the Brunei building construction industry, with its different environmental, political and cultural issues, other possible reasons could be due to the immature construction industry and personnel capabilities in the construction industry.

The findings of this survey result in a new hierarchy for the seven critical success factors in avoiding the delay factors in building construction processes. It is based on the importance of critical success factors identified in this research. This will address the gap in the research literature.

8.1.6. Delphi Technique (Ranking from expert panel)

The panel viewpoint obtained in the Delphi study is summarised statistically; a two-round Delphi was achieved in the research and the results are as follows. The first round responses of the Delphi survey were tabulated in chapter 7 and analysed using a distribution ranking table to annotate the average ranking, median ranking and the order of importance of each strategy, as indicated in Table 7.2. The first round Delphi from expert panels result in the ranking of the critical success factors as follows:

1. *Project manager capabilities*
2. *Clarity of project scope and work definition*
3. *Organisational planning*
4. *Use of control system*
5. *Project manager's goal commitment*
6. *Project team motivation and goal orientation*
7. *Safety precaution and applied procedure*

The results of the responses of the strategy ranking and importance from two rounds of the Delphi surveys were tabulated, averaged and used to validate each strategy ranking of importance. The final ranking for the most important critical success factors for building construction projects are represented in Table (7.3) in Chapter 7. These are:

1. *Project manager capabilities*
2. *Clarity of project scope and work definition*
3. *Organisational planning*
4. *Use of control system*
5. *Project manager's goal commitment*
6. *Project team motivation and goal orientation*
7. *Safety precaution and applied procedure*

8.2 STUDY CONCLUSION

The research identified the critical delay factors in the construction process for building construction projects in Brunei Darussalam. Critical delay factors which were identified are *lack of communication, slow decision making, change orders, inadequate contractor planning, finance and payment of completed work, subcontractors, and inadequate contractor experience*.

The similarity of several findings regarding delay factors in this research compared to previous research findings from other developing countries confirmed that project stakeholders in different developing countries face similar problems in spite of different natural, economic, political and social backgrounds (Ogunlana and Olomaiye – 1989). The difference is found in the priorities of the most important factors for delay. This indicates that there are special problems that generate delays in construction in terms of the culture, environment and political situation of the country.

This research has demonstrated that there is strong agreement between groups (owners, contractors, and engineers) on the correlation between critical delay factors and critical success factors. This leads us to conclude that owners, contractors and engineers are largely in agreement with regards to their evaluation of success factors that avoid delay factors. In this research a new hierarchy scheme for the seven critical success factors in avoiding the identified critical delay factors has been created, based on the importance of critical success factor outcomes from this research. The critical success factors for the building construction process will address the gap in the research literature in the construction industry. These factors are:

1. *Project manager's capabilities and experience(S5);*
2. *Organisational planning(S1);*
3. *Clarity of project scope and work definition(S4);*
4. *Use of control systems(S7);*
5. *Project manger's goal commitment(S2);*
6. *Project team motivation and goal orientation(S3);*
7. *Safety precaution and applied procedures (S6).*

The priority of success factors identified in this research is not reflected in the literature because in this research, success was defined more broadly than just delay. For example, *organisational planning (S1)* was ranked the most important factor in the literature, but in this research it was ranked the second most important success factor. The most important success factor identified in this study, *project manager's capability and experience (S5)* was ranked fifth in the literature.

*Use of control system*s *(S7)* was ranked the 7th most influential success factor in the literature (Ashley et al, 1987), whilst in this research it was ranked 4th. The success factors ranked 2nd and 3rd in the literature (Ashley et al ,1987) as the most important success factors were *project manager's goal commitment (S2)* and *project team motivation and goal orientation (S3)*. In this research, *project manager's goal commitment (S2)* was ranked 5th and *project team motivation and goal orientation (S2)* was ranked 6th. *Safety precaution (S6)* was ranked the 7th most important success factor in this research, but only 6th in the literature, (Ashley et al, 1987).

This discrepancy in the ranking of success factors could be explained in a number of ways. First, this research limited the number of success factors to seven, which may have affected their priority. Secondly, the research focused on the delay factors relevant to the building construction process, whilst the literature mostly identified success factors based on overall construction projects, or on a particular segment of a construction project such as productivity, quality or procurement. Thirdly, the target project was a public project, and was evaluated by different project participants. The literature on critical success factors focused on private projects, or both public and private projects. Finally, this study was also restricted to the Brunei building construction industry, with its different environmental, political and cultural issues. Given the research circumstances and conditions, the hierarchy derived from this study is consistently supported by the results from all three groups (owners, contractors and engineers).

Compared to other studies in other countries on critical delay and success factors, there are similar problems on delay factors and critical success factors identified in the construction industry. However the difference can be found in the ranking of the most critical success and critical delay factors. This could be due to the countries' immature construction industry, personal capabilities in developing countries, and social, culture and environmental problems in different countries.

Finally, the use of consensus-forming techniques allowed the merging of experts' opinions in order to rank the best means of achieving a better performance for Brunei building construction projects. Theoretically, the Delphi process can be continuously iterated until consensus is determined to have been achieved. However, Cyphert and Gant (1971), Brooks (1979), Ludwig (1994, 1997), and Custer, Scarcella and Stewart (1999) point out three iterations are often sufficient to collect the needed information and to reach a consensus in most cases.

Two round Delphi were achieved to determine the consensus opinion in this study. The objective of the Delphi technique used was to determine a range of possible program alternatives based on the list of critical success factors. Secondly, the selected panel were equivalent in knowledge and experience in construction, and the panel members are policy and strategy decision makers who will utilise the outcomes of the Delphi technique. When panel members are also strategic decision makers, Delphi moves from being a group forecasting tool to facilitating group decision making by ensuring the most rational policies emerge under a different set of working conditions and resource constraints such as exists in the Brunei construction industry.

The final ranking list is as follows:

1. *Project manager's capabilities and experience*
2. *Clarity of project scope and work definition*
3. *Organisational planning*
4. *Use of control systems*
5. *Project manger's goal commitment*

6. *Project team motivation and goal orientation*
7. *Safety precaution and applied procedures.*

The group overall importance of success factors on delay factors for the building construction industry were found to be of a different order, primarily for two factors, *clarity of project scope and work definition and organisational planning,* in the final ranking of Delphi survey. This could also be due to the countries' immature construction industry, personal capabilities in developing countries, and social, culture and environmental problems in different countries.

The aim of the research is to improve project management performance in Brunei's construction industry. Findings in this research assert that the critical success factors perceived as most influential in avoiding or preventing critical delay factors can lead to better performance within construction industries and they are likely to improve success in building construction projects. Consensus expert opinions were used to identify the most needed critical success factors to take into account when considering how to improve project performance in Brunei's building construction industry.

8.3 LIMITATION OF THE RESEARCH

Some limitations to this research were identified during the development of the questionnaire, and during the data collection and analysis phase. However despite the limitations as described below, the researcher was still able to achieve valid data for this research. These limitations are:

- Data collection took place during a season in which most of the targeted expert panel members and engineers were on vacation. This had a negative impact on the response rate. However a significant and representative sample was still able to be achieved.

- Since this is the first research to evaluate the delay factors and success factors of building construction projects in Brunei, there is no past research with which to compare the results of this research.

- The project team for the project survey was no longer working in Brunei and some data was collected from the project reports.

- Despite requests from respondents for new, unique, or unlisted success or delay factors, few such responses were given.

- The targeted project cases differed according to project type, designer type, kind of contract, and contractor classification.

- The projects surveyed used a traditional contract, where this is the most popular contract method used in public projects in Brunei.

8.4 CONTRIBUTION OF THE RESEARCH

The present study will contribute to the field by integrating knowledge about critical success factors, as well as what is known about critical delay factors. By learning which critical success factors are perceived as most influential in avoiding or preventing critical delay factors, this study can lead to better performance within construction industries. Although the research study presented here was based in Brunei Darussalam, it is anticipated that these results would be broadly applicable to other developing countries.

A unique strength of the present study, aside from being the first to investigate the relationship of critical success factors identified in the literature, and delay factors identified in building construction process, is that it collected data from owners, contractors and engineers working on the same projects. Separate survey data was also collected from owners, contractors and engineers on the correlation of the critical delay factors and critical success factors, based on their general experience. Consensus expert opinions were used to identify the most needed critical success factors when considering how to improve project performance in Brunei's building construction industry.

Finally this research can be used for future studies that examine critical success and delay factor relationships. The identification of the success factors for the construction process investigated in this research formed an empirical study for future research on critical success factors in the building construction industry.

8.5 RECOMMENDATIONS FOR FUTURE RESEARCH

Future studies examining the effects of critical success factors to avoid or prevent delay factors in the construction industry should consider the following suggestions:

- Brunei lacks empirical research in this area of study. This study will therefore be the first of its kind to investigate the key success factors for project success in Brunei's building projects. It is anticipated that this study will derive a foundation on which further local research can be conducted for the improvement of project performance in the construction industry.

- Further research is needed to investigate potential improvements in the implementation of project management systems in Brunei's construction Industry. The critical success factors in this study can be used to investigate this. Efficient project management would result in tangible outcomes for all aspects of planning, scheduling and monitoring control of time, cost and specification of projects. Implementing efficient management methods will overcome political, organisational and cultural obstacles

- The critical success factors found to be most influential in this study could be utilized in future work which examines different situations and environments. For example one could look specifically at industrial facilities, or private sector projects. The same scientific methodology can be used to rank the correlation of the success factors and delay factors.

- Applying the same study criteria to different procurement methods, for example design and build, turnkey etc., could be valuable for the construction industry to adopt a new approach to contracting and contract award procedures, and will provide better control systems.

- One could relate this study's ideas with a focus specifically on projects that experience significant delays, quality, productivity, or cost overrun. There is the potential to develop a mathematical model ranking the success factors for the construction process under different headings in a hierarchical manner.

- It is recommended that the methodology used in this research should be applied to other countries, thereby increasing the data available for future comparisons of different delay causes and critical success factors. This will identify the criteria of each of the critical success factors for relevance and adaptability to develop and developing countries.

- The use of consensus forming techniques allowed the merging of expert opinions to rank the critical success factors to improve project performance in the construction industry. The outcome of ranking the critical success factors showed how these can be used to investigate the best processes to enable the government to enhance project performance. Further discussion to consider future policies and strategies aimed at integrating and improving the construction industry is also an option.

REFERENCES

Abdul-Rahman., Berawi H., Berawi M.A., Othaman M., and Yahya I.A. (2006), Delay mitigation in the Malaysian Construction industry, *Journal Construction Engineering Management,* 132(2), pp.125-133

Altschuld J.W. & Thomas P.M.(1991), Considerations in the application of a modified screen test for Delphi survey data, *Evaluation Review,* 15(2), pp179-188

Adams J.R, & Brandt S.E. (1983), Behavioral implications of the project lifecycle In D.I Cleland. & W.R King. (Eds), *Project management handbook* (pp 183 -204). New York: Van Nostrand Reinhold Co

Ahmed S.M., Azhar.S.,Kappagntula,P. and Gollapudil. D. (2003), "Delays in construction: a brief study of the Florida construction industry", *Proceedings of the 39th Annual ASC Conference, Clenson University, Clenson, SC,* pp257-266

Alghbari W.A.M. (2005), "Factors affecting construction speed of industrialized building system in Malaysia", *Master's thesis, University Putra Malaysia, Serdang*

Aibinu A.A and Jagboro J.O. (2002), The effects of construction delays on project delivery in Nigerian construction industry, *Int J Project Management* 20, pp.593– 599

Akinsola A.O., Potts K.F., Ndekugri I., & Harris, F.C. (1997), Identification and evaluation of factors influencing variations on building projects, *International Journal of Project Management, V*ol .15,(4), pp. 263-267

Albert, P.C Chan., David Scott & Ada, P.L.Chan (2004), Factors affecting the success of a construction project, *Journal of Construction Engineering and Management*, Vol .130,(1), pp.153 – 155

Al-Momani A. (1996), Construction delay: a quantitative analysis techniques, *Construction Manage Econ* 14 (5), pp. 375-394

Al-Momani A.H. (2000), Construction delay: a quantitative analysis, *International Journal of Project Management,* 18, pp. 51-59

Altschuld J.W. & Thomas P.M. (1991), Considerations in the application of a modified screen test for Delphi survey data, .*Evaluation Review,* 15(2), pp 179-188

Angela, Clarke. (1999), A practical use of key success factors to improve the effectiveness of project management, *International Journal of Project Management*, Vol .17, No. 3, pp.139 -145

Arditi D., Gunayadin H.M (1998), Factors that affect process quality in the life cycle of building projects, *Journal Construction Eng Manage*, ASCE 124(3) pp 194-203

Armstrong J. Scott. (1978), *Long Range Forecasting*, John Wiley, New York

Ashley & Jaselskis (1987), Determinants of construction project success, *Project Management Journal,* Vol .18, (2), pp.69 – 79

Assaf S.A., Alkhalil M., Al-Hazmi M. (1995), Causes of delay in large building construction projects, *Journal of Management in Engineering,* ASCE 11,(2) pp.45-50

Avots I (1969), Why does project management fail? .*California management review*, 12,(10),pp. 77-82

Baker,B.N., D.C. Murphy and D. Fisher (1988). Factors affecting project success. *International Project Management Handbook ed. D.I.Cleland and W.R.King* 2nd edition 902 -919, New York

Baldwin J.R and Manthel J.M.(1971), Causes of delay in the construction industry. *Journal of Construction Division, ASCE,* 97, pp. 177-187

Barnes M. (1987), Construction Project management, Seminar on "Construction Project Management, 21-22 October, London, England, 1987

Barnes N.M.L, and Wearne S.H. (1993), The future of major project management. *International Journal of Project Management*, 11(3), pp. 135 - 142

Beale, P. and Freeman M. (1991), Successful project execution: a model. *Project Management Journal*, 4 (December), pp. 23-30

Bedelin H.M (1996), Successful major projects in a changing industry. *Civil engineering*, April, pp. 55-63

Belassi W., & Tukel O.I. (1996), A new framework for determining critical success/failure factors in projects. *International Project Management*, Vol.14,(3), 141-151

Belout A. (1998), Effects of human resource management on project effectiveness and success: towards a new conceptual framework, *International Journal of Project Management,* Vol.16(1), pp. 21-26

Bennet R. (1991), How is management research carried out? *The Management Research Handbook*, Smoth N.C. and Danity P.(eds), Rouledge, London pp 83-103

Bentley D. and Raftery G. (1992), Project management: key to success. *Civil Engineering*,April, pp. 58-59

Brunei Darussalam, Long *Term Development Plan*, (2017 -2012)

Brunei Darussalam, *Economic Development Annual Report*, (2005)

Brooks K.W. (1979), Delphi Technique: Expanding applicatons, *North Central Association Quarterly*, 53 pp 377-385

Bowden A & Gren, P. (2005), Doing phenomenography (Qualitative research methods series). Melbourne, Vic: RMIT Publishing

Cash C. and Fox R. (1992), Elements of successful project management. *Journal of System Management*, pp. 10-12

Chalabi F.A. & Camp D. (1984), Causes of delays and overruns of construction Projects in developing countries, *CIB Proceedings*, no. 2, pp. 723-734

Chan A.P.C., Scott D., & Lam E.W.M. (1999). Critical success factors for different project objectives. *Journal Construction Engineering Management*, Vol 18(3), pp 120 -128

Chan D.W.M., & Kumaraswamy M.M. 1996), An evaluation of construction time performance in building industry. *Building and Environment,* 31(6) pp 569-578

Chan D.W.M & Kumaraswamy M.M. (1997), A comparative study of causes of time overruns in Hong Kong construction projects. *Journal Management Engineering,* Vol 15(1): 55 -63

Chan D.W.M., & Kumaraswamy M.M. (1998), Contributors to construction delays. *Construction Management and Economics,* 16 pp. 17-29

Chan D. W. M and M.M. Kumaraswamy M.M.(2002), A comparative construction durations: lessons learned from Hongkong building projects, *Int J Project Manage* 20 , pp. 23-35

Chan H.D.C and C.M.Tan (1995), Impact of management styles on project performance, *Published in the proceedings of the first International Conference on Construction Project Management, Singapore* pg 227 -233.

Chen Y., Zhu D., and Li, C. (1990), Application of the Delphi Method in China, *Technological Forecasting and Social Change*, 38, pp 293-304

Chia Chien Hsu & Brian A Sandford. (2007), The Delphi Technique: Making Sense of Consensus. *Practical Assessment, Research & Evaluation,* 12(10) pp. 1-7

Chua D.K.H., Kog T.C., && Loh P.K. (1999), Critical success factors for different project objectives. *Journal construction Engineering Management,* Vol 125(3), pp. 142 -150

Chua D.K.H and Loh P.K. (1997), Neural networks for construction project success. *Expert Systems with Applications*, Vol 13(4), pp.317-328

Clarke A. (1999), A practical use of key success factors to improve the effectiveness of project management, *International Journal of Project Management,* 17(3), pp. 139-145

Cleland D.I. & King W.R (1983), *Systems analysis and project management*. McGraw Hill, New York, Concept, 2004, http://www.concept.ntnu.no

Code of practice of Project Management for Construction and Development (2002), 3rd edition. *The Chartered Institute of Building*

Daniel W.M.Chan.,and Mohan M. Kumaraswamy . (1997), A comparative study of causes of time overruns in Hong Kong construction projects, *International Journal of Project Management,* 15(1), pp. 55-63

De Wit, A. (1988), Management of project success. *International Journal of Project Management* 6(3), pp.164 – 170

D.K.H.Chua.,Y.C.Kog and P.K.Loh.(1999), Critical success factors for different project objectives. *Journal of Construction Engineering and Management* may/june 1999

Dale Christenson & Derek H T Walker (2004), Understanding the role of "vision" in project success, *Project Management Journal,* Vol. 35, No. 3, pp.39 -53

Dalkey N.C. (1967), *Delphi.* Santa Monica, CA: The RAND Corporation

Dalkey N.C., & Helmer O. (1963), An experimental application of the Delphi method to the use of experts. *Management Science*, 9,(3), pp 458-467

Dissanayaka S.M., & Kumaraswamy M.M. (1999a), Comparing contributors rme and cost performance in building projects, *Building and Environment*, 34, pp 31-42

Dissanayaka, S.M., & Kumaraswamy, M.M (1999b), Evaluation of factors affecting time and cost performance in Hong Kong building projects, *Engineering Construction Architect Management,* vol. 6,(3), pp. 287 -298

Edward J, Jaselskis & David B, Ashley, (1991), Optimal of project management resources for achieving success*. Journal of Construction Engineering and Management,* Vol .11, June 1991 No 2

Frame J.D. (1994*). The new project management: Tools for an age of rapid change, corporate and other business realities*.Jossey Bass Inc

Frimpong Y., Oluwoye J and Crawford L. (2003), Causes of delay and cost overruns in construction of groundwater projects in a developing countries; Ghana as a case study, *Int J Project Manage* 21 , pp. 321-326

Gale A.W. & Fellows R.F. (1990), Challenge and innovation: the challenge to the construction industry, *Construction Management and Economics,* 8 pp. 431-436

Gena L. Abraham. (2003), Critical success factors for the construction industry, *Construction research congress, winds of change:integration and innovations in construction, proceedings of the congress,*pp 521-529

Ghaleb Y.Abassi & Hisham Al-Mharmah (2000): Project management practice by public sector in a developing country, Vol.18,(2),pp.105 – 109

Green P.J. (1982 March), *The content of college level author leadership course.* Paper presented at the Conference of the Northwest District Association for the American Alliance for Health, Physical Education, Recreation and Dance, Spokane, WA

Hatush Z., and Skitmore M. (1997), Evaluating contractor pre-qualification data: selection criteria and project success factors, *Construction Management and Economics,* 15, pp. 129-147

Hassan A.Q.(1995). Don't burn the bridge, *Journal Management Engineering*. Vol 11(6), pp.22

Hasson F., Kenney S., & McKenna H. (2000), Research guidelines for the Delphi Survey technique, *Journal of Advanced Nursing,*32(4) pp.1008-1015

Helmer O. (1967), *Systematic use of expert opinions* (Report No P-3721). Santa Monica, CA: The RAND Corporation

Helmer O. (1977), Problems in Futures Research – Delphi and Casual Cross Impact Analysis, *Futures* 9, pp.17-31

Helmer O. (1983), *Looking forward: A guide to future research.* Beverley Hills, CA: Sage

Hensey M. (1991), Essential success factors for strategic planning, .*Journal of Management in Engineering*, 7(2), April,.pp .167-177

Hubbard D.G (1990), Successful utility project management from lesson learned, *Project Management Journal.,* 21(3), pp. 19-23

Hughes M.W. (1986), Why project fail: The effect of ignoring the obvious. *Ind Eng* (1986),Vol.18,pp.14 -18

Hussey.Jill & Hussey.Roger (1997). *Business Research,* A Practical guide for undergraduate and postgraduate students.

Isaac S. & Michel W.B. (1981), *Handbook in research and evaluation.* San Diego, CA: EdiTS Publishers

Jaselskis E. and Ashley D.B. (1988), Achieving construction project success through predictive discrete choice models in Association of Project Managers, *Proceedings 9th World Congress Project Management,* September, 4-9, 1988, Glasgow, Scotland pp. 71-85

Jaselskis E.J. and Ashley D.B. (1991), Optimal allocation of project management resources for achieving success. *Journal Construction Eng Management.,Vol.* 117(2), pp.321-340

Jeffery K.Pinto. & Dennis P.Slevin. (1987), Critical success factors in successful project implementation. *IEEE transaction on engineering management,* 34(1), pp. 22-27

Jeffery K.Pinto. & O.P.Kharbanda (1988). Successful project managers: Leading your team to success

Jha K.N. and Lyer K.C. (2004). Critical factors affecting quality of Indian construction projects. *World Construction of Project Management*.1st International conference may 27 2004 – may 28 2004, Toronto Canada

Kamming P.F., Olomaiyr P.O., Holt G.D., & harris F.C. (1997).Factors influencing construction time and cost overruns on high-rise projects in Indonesia. *Construction Management Economics, Vol* .15(1), pp. 83 -94

Kezner H. (1998). *Project management: A system approach to planning and controlling (6th Ed),* Van Nostrand Reinhold

Kezner Harold. (2006*). Project management: A system approach to planning and scheduling (7th Ed),* Van Nostrand Reinhold

Kog Y.C. et.al, (1999), Key determinants for construction schedule performance. *International Journal of Project Management,* 17(6), pp. 351-359

Koontz H. & O'Donnell G. (1976), *Management: A system and contingency analysis of managerial functions* (6th edition). New York: McGraw Hill

Kothari A.K. (1986), Success in project management. In Project Management Institute *Proceedings of the Project Management Institute*, September 20-25, 1986, Montreal, Canada:Drexel Hill, pp.240-245

Kumaraswamy M. and Chan D. (1998), Contributors to construction delay, *Construct manage Economic*, 16 (1), pp.17 -29

Lechler T. (1998), When it comes to project management, it's the people that matter, An empirical analysis of project management I Germany, IRNOPIII, The nature and role of projects.

Lim C.S.& Mohammed M.Z., An explatory study into recurring construction problem.(2000), *International Journal of Project Management*, 18(3), pp. 267-273

Linn C. Stuckenbruck. and Asghar Zomorrodian. (1987), Project management: the promise for developing countries, 5(3) August.

Linstone H. & Turoff M. (1975), *The Delphi Method: Techniques and Applications,* Addison-Wesley, London

Locke D. (1984), *Project Management*. St Martins Press, New York.

Ludwig B. (1997). Predicting the future: Have you considered using the Delphi methodology? *Journal of Extension,* 35 (5) pp 1-4 Retrieved November 6 2005 from http://www.joe.org/joe/1997october/tt2html

Madu C., Kei C. & Madu A, (1991), Setting Priorities for the IT industry in Taiwan – A Delphi Study, *Long Range Planning,* 24(5),pp.105-118

Martin C.C. (1976), Project Management.Amaco, New York P. (1987), Delphi Revisited: Expert Opinion in Urban Analysis, *Urban studies*, 24 pp. 217-225

Mansfield N.R., Ugwu O.O., & Doran T. (1994), Causes of Delay and causes of overruns in Nigerian construction projects, *International Journal of management,* 12(4), pp.254-260

Masser I. and Foley P. (1987), Delphi revisiter: expert opinion in urban analysis, *Urban Studies*, 24, pp. 217-225

Mohammed M. Alkhathami. (2004), *Examination of the correlation of critical success and delay factors in construction projects in Kingdom of Saudi Arabia*, Ph.D. dissertation, school of engineering, University of Pittsburgh.

Mc Cuen R.H ed. (1996). *The Elements of Academic Research,* ASCE press, New York

Mengesha Wubishet Jekale. (2004). *Performances for Public Construction Projects in Developing Countries: Federal Road & Educational Building Projects in Ethiophia* Norwegian University of Science and Technology: Doctoral Thesis 2004: 45

Meredith, J. R. & Mantel, S. J. (1989), Project Management : A Managerial Approach, John Wiley and sons, Canada.

Manavazhia M.R. and D.K. Adhikarib, Material and equipment procurement delays in highway projects in Nepal, *Int J Project Manage,* 20 (2002), pp. 627-632

Miller L.E. (2006 October), *Determining what could/should be: The Delphi technique and its application.* Paper presented at the meeting of the 2006 annual meeting of the Mid-Western Educational Research Association, Columbus Ohio

Mitroff I.L. & Turoff M. (1975). Philosophical and methodological foundations of Delphi. In H.A Linstone & M. Turoff (Eds), *The Delphi method: Techniques and applications* (pp 17-35). Reading MA:Addison-Wesley Publishing Co

Moavenzadeh F. & Hagopian, F. (1984), The construction industry and economic growth, *Asian National Development,* June/July, pp. 56-60

Morris P.W.G. (1983), Managing project interfaces – key points for project success, *Project Management handbook,* D.I Cleland and W.R.King, eds., Van Nostrand Reinhold Co., New York, N.Y., pp 3-36

Morris P. W., & Hough, G. H (1987), *The Anatomy of major projects,* John Wiley and Sons, New York

Muhammad Imran Yousuf. (2007), Using Expert's Opinions 'Through Delphi Technique', *Practical Assessment ,Research & Evaluation,*(2007), 12(4), pp. 1- 5

Murali Sambasivan. & Yau Wan Soon. (2007), Causes and effect of delays in Malaysian Construction Industry, *International Journal of Project Management.*

Muspratt M. (1987), Conditions affecting projects in less developed countries, *Project Management,* 5(1), pp.45-53

Nguyen DL, Ogunlana SO, Quang T and Lam KC. (2004), Large construction projects in developing countries: a case study from Vietnam, *International Journal of Project Management, Elsevier*, 22(7), pp. 553-561

Nguyen DL, Ogunlana S and Lan DT. (2004), A study on project success factors in large construction projects in Vietnam. *Engineering Construction and Architectural Management*, 11(6), pp404-413

Noulmanee A., Wachirathmrojn J., Tantiichattanont P., Sittivijan P. (1999), Internal causes of delays in highway construction projects in Thailand

Nunnally S.W. (2004), Construction method and management, *Sixth edition, Person Education, Inc*

Odeh A. M and Bettaineh H. T. (2002), Causes of construction delay: traditional contracts, *Int J Project Manage Property Construction* 20, pp. 67-73

Odussami K.T, Iyegba R.R.O & Ominn M.M. (2003), The relationship between project leadership, team composition and construction project performance in Nigeria, *International Journal of Project Management.* Vol. 21, No. 7, pp .519-527

Ofori G. (1990), The Construction Industry: Aspects of its Economics and Management. Singapore University Press, Singapore

Ofori G. (1994), Practice of construction industry development at the crossroads, *Construction and Architectural Management,* Vol. 3, No.4, pp. 271-288

Ofori G. (2000), Challenges of construction industries in developing countries: lessons from various countries. *Proceedings of the 2nd International conference of the CIB TG29 on Construction in Developing Countries: Challenges facing the construction industry in developing countries,* 15 -17 November 2000, Gabarone, Botswana,pp. 40-50

Ofori G. (2001), Indications for measuring construction industry development in developing countries, *Building Research Environment,* 24(2), pp.191-196

Ogunlana S. O. & Krit Prumkuntong. (1996), Construction delays in a fast growing economy: Compare Thailand with other countries. *International Journal of Project Management* 14 (1), pp.37-45

Olav Torp Kjell Austerg & Wubished Jekae Mengesha., Critical success factors for project performance:

PMBOK (2004), A guide to project management body of knowledge.

Parfitt M.K., & Sanvido V.E. (1993), Checklist of critical success factors for building projects, *Journal of management in engineering,* 9(3), pp.243-249

Partfit M.K. (1989), Key factors for success in building project delivery, *Report of Symp on key factors in Building Project Delivery Systems,* Penn State Consortium for the Advancement of Building Sciences, pp. 1-7

PintoJ.K. & Selvin,D.P. (1987), Critical factors in successful project implementation, *IEEE Trans Eng Management*. Vol. 34, pp. 22-27

Pinto J. & Dennis P, Project Success: definitions and measurement techniques. *Project Management* Journal XIX 1 (1988), pp. 67-72

Pinto J.K. and Prescott J.E. (1988). Variations in critical success factors over the stages in the project cycle, *Journal of Management*, 14, pp. 67-75

Pinto J.K., & Prescott J.E. (1990), Planning and tactical factors in the project implementation process. *Journal Management Studies* 305 -325

Pinto J.K and Selvin D.P. (1983, Critical success factor in R & D projects*. Research Technology Management,* 32, pp.31-33

Pinto J.K and Selvin D.P (1988), Critical success factors across the project life cycle. *Project Management Journal*, 19(3), pp. 67 – 75.

Pinto J. & Kharbanda, O.P., 1995, *Successful Project Managers: Leading your team to success* New York: Van Nonstrand Reinhold

Reich Y. (1994), Layered models of research methodologies, artificial intelligence for engineering design. *Analysis and Manufacturing*, vol.8, pp. 263-274

Rieger W. (1986), Directions in Delphi Developments: Dissertations and Their Quality, *Technological Forecasting and Social Change,* 29, pp.195-204

Rodney Turner J, Ralf Muller (2005), The project manager's leadership style as a success factor on projects: A literature review. *Project Management Journal,* Vol. 36, No 2, pp. 49 -62

Rockart J.F. (1979), Chief executives define their own data needs. *Harvard Buisness Review,* Mar – April, pg 85

Rockart J.F. (1982), The changing role of information system executive: A critical success factors perspective

Rohatgi K., and Rohatgi P.(1979), Delphi as a Tool for identifying Future Appropriate Technologies in India, *Technological Forecasting and Social Change*, 14, pp.65-76

Rowe G., Wright,G., and Bolger F.(1991), Delphi: A Reevaluation of Research and Theory, *Technological Forecasting and Social Change* 39, pp.235-251

Rubin I.M & Seeling W.(1967), Experience as a factor in the selection and performance of project managers. *IEEE Trans Eng Management*., Vol.14 (3), pp. 131-134

Sadi A. Assaf & Sadiq Al-Hejji .Causes of delay in large construction projects, *Int J Project Manage, (2006),* 24(4), pp. 349 -357

S.A. Assaf, M. Alkhalil and M. Al-Hazmi.(1995), Causes of delay in large building construction projects, *J Manage Eng, ASCE* 11(2), pp. 45-50

Sanvido V., Grobler F., Pariff K., Guvens M., & Coyle M. (1992), Critical success factors for construction projects,. *Journal Construction Engineering Management,* Vol .118(1), pp.94-111

Scheele D.S. (1975), Reality construction as a product of Delphi interactions. In H.A.Linstone & M Turoffs (Eds), *The Delphi method: Techniques and applications* (pp 37-71). Reading MA: Addison Wesley Publishing Company

Skutsch M., & Hall D. (1973), Delphi Potential uses in education planning. In J.L Barnes, (1987), *An international study of curricular organizers for the study of technology.* Unpublished doctoral dissertation, Virginia Polytechnic Institute and State University, Blacksburg, Virginia

Stone E.F. (1978), Research methods in organizational behaviour, Goodyear publishing company, Santa Monica, CA

Strauss, Anslem and Colon, Juliet (1990), *Basic of qualitative research*, Newbury park sage.

Stuckenbruck L. and Asghar Z (1987), Project management: the promise for developing countries, *Project Management,* 5(3), pp.167-175

Songer A.D, and Molenaar K.R, (1997), Project characteristics for successful public-sector design-build. *Journal Construction Eng Management,* 123(1), pp.34-40

Sweis G., Sweis R., Abu Hammad A., & Shboul A.(2008), Delays in construction projects : The case of Jordan, *International Journal of Project Management,* 26, pp.665-674

Syed M.Ahmed., Salman Azhar., Pragnya Kappagantula., and Dharam Gollapundi. (2003), Delays in Construction: A brief study of the Florida construction industry, *ASC proceedings of the 39th Annual Conference, Clemson University –Clemson, South Carolina,* pp. 257-266 http://asceditor.unl.edu/archives/2003/Ahmed03.htm

Tommy Y. Lo., Ivan W.F.Fung., and Karen C.F.Tung (2006), Construction delays in Hong Kong civil engineering projects, *Journal of Construction Engineering and Management,* 132(6) pp.636-649

Toor S.R. and Ogunlana S.O (2008), Critical COMs of success in large scale construction projects: Evidence from Thailand construction industry, *International Journal of Project Management*, 26, pp. 420-430

Toor S.R. and Ogunlana S.O (2008), Problems causing delays in major construction projects in Thailand, *Construction Management and Economics* 26 pp 395-408

Tukel O.I & Rom W.O (1995), Analysis of the characteristics of projects in diverse industries working paper, *Cleveland State University, Cleveland Ohio*.

Turin D.A (1973), *The Construction Industry*: Its *Economic Significance and Its Role in Development, (*2nd ed), University College Environmental Research Group UCERG, London

Turner J. R and R.Muller (2003), On nature of project as temporary organization. *International Journal of Project Management*, 21(1)

Trigwell K. (2000), Phenomenography: Variation and dissenment, Improving student learning*. Proceedings of the 1999 7th International symposium*, Oxford, Oxford centre for staff and learning department.

Ubaid A.G. (1991), Factors affecting contractor performance. Master thesis, CEM Dept., KFUPM, Dhahran, Saudi Arabia

United Nation Industrial Developments Organisations, UNIDO (1993), Prospects for the Development of the Construction Industry in Developing Countries, ID/WG. 528/5, Vienna

Van Dijk J.(1990a), Delphi Questionnaires versus Individual and Group Interviews: A Comparison Case, *Technological Forecasting and Social Change,*37, pp.293-304

Van Dijk J. (1990), Delphi Method as a Learning Instrument: Bank employees discussing automation project, *Technological Forecasting and Social Change*, 37, pp.399-407

Van Dijk J.A.G.M. (1990), Delphi questionnaires versus individual and group interviews: A comparison case. *Technological Forcasting and Social Change,* 37 pp.293-304

Vasantha Abeysekara & Campbell Melean (2001), Seventh annual conference University of Salford

Victor Sanvidor (1992), Critical success factors for construction projects. *Journal of Construction Engineering and Management*, 118(1)

Wateridge J.F (1995), IT projects: a basis for success. *International Journal of Project Management,* Vol.13, No. 3, pp.169 -172

Waissbluth M., and de Gortari A.(1990), A Methodology for Science and Technology Planning Based Upon Economic Scenarios and Delphi Techniques: The Case of Mexican Agro industry, *Technological Forecasting and Social Change,* 37, pp 383-397

.Walid Belasi & Oya Icmeli Tukel (1996), A framework for determining critical success/failure factors in projects, Vol. 14 (3), pp.141-151

Walke, D.H.T.(1995), An investigation into construction time performance. *Construction Management Economic*.,Vol. 118(1), pp.94 -111

Walker D.H.T (1997), An investigation into construction time performance, *Construction Management Economic.,* 13(3), 263-274

Walker D.H.T., & Vines, M.W. (2000), Australian multi-unit residential project construction time performance factors. *Engineering Construction Architect Management.*Vol. 7(3), pp. 278 -284

Webler T., Levine D., Rakel H., and Renn O.(1991), A Novel Approach to Reducing Uncertainty: The Group Delphi, *Technological Forecasting and Social Change*, 39 pp. 253-263

Wells J. (1986), *The Construction Industry in Developing Countries: Alternative Strategies for Development.* Croom Helm Ltd, London

Williams Terry (2003), Assessing extension of time delays on major projects, *Int journal Project Manage,* 21, pp.19-26

Witkin B.R & Altshuld J.W. (1995), *Planning and conducting needs assessment: A practical guide.* Thousand Oaks, CA: Sage Publications, Inc

World Bank (1984), The Construction Industry: Issues and Strategies in Developing Countries, International Bank for Reconstruction and Development, World Bank, Washington, D.C.

Worthen B.R., & Sandlers J.R. (1987), *Educational evaluation: Alternative approaches and practical guidelines.* New York: Longman

Yin R, K. (1994), *Case study research: Design and methods (2nd ed)* Sage Publication

Yin R.K. (2003), *Case Study Research: Design and Methods*, Thousands Oaks, Calif., Sage Publications, 2003. 3rd ed

Young S.J., & Jamieson L.M. (2001), Delivery methodology of the Delphi: A comparison of two approaches. *Journal of Park and Recreation Administration,* 19(1), pp.42-58

Yuxiang, C., Donghua, Z, and Changgeng, L. (1990), Applications of the Delphi Method in China, *Technological Forecasting and Social Change*, 38, pp.293 -305

APPENDICES

APPENDIX A – GROSS DOMESTIC PRODUCT BY ECONOMIC ACTIVITY

Appendix A1 – Gross Domestic Product Average Annual Growth Rates By Kind of Economic Activity during RKN6, RKN7 and RKN8

SECTOR	AVERAGE ANNUAL GROWTH		
	RKN6 1991-1995	RKN7 1996-2000	RKN8 2001-2005
I. AGRICULTURE, FORESTRY AND FISHERY	1.7	6.9	7.0
II. INDUSTRIAL SECTOR	3.7	0.9	1.3
1. Mining	3.1	1.6	0.7
2. Manufacturing	3.9	2.5	1.3
3. Construction	8.2	11.9	8.4
4. Electricity and Water	7.3	6.2	3.3
III. SERVICES SECTOR	2.2	2.0	3.3
1. Transport & Communication	2.5	2.9	2.1
2. Trade	3.7	1.6	5.5
3. Finance	4.1	4.8	5.3
4. Real Estate & Ownership of Dwellings	4.0	6.1	0.9
5. Private Services	3.8	3.3	4.5
6. Government Services	2.8	0.8	2.7
GROSS DOMESTIC PRODUCT	3.2	1.3	2.7

Source: Brunei Darussalam Long-Term Development

Appendix A2 – Gross Domestic Product by Kind of Economic Activity at Current and Constant prices, 2000 – 2005 Brunei Darussalam

Jenis Aktiviti Ekonomi	Nilai (BND juta) / *Value (BND million)*												Kind of Economic Activity
	Pada Harga Semasa *(At Current Prices)*						Pada Harga Tetap *(At Constant Prices)*						
	2000	2001	2002	2003	2004^r	2005^p	2000	2001	2002	2003	2004^r	2005^p	
PERTANIAN, PERHUTANAN & PERIKANAN	106.0	113.9	114.4	139.6	150.0	150.2	106.0	112.2	118.0	131.3	147.1	149.0	*AGRICULTURE, FORESTRY & FISHERY*
SEKTOR INDUSTRI	6,587.3	6,025.5	6,347.1	7,328.3	9,028.4	11,352.4	6,587.2	6,642.0	6,940.5	7,182.2	7,142.9	7,015.0	*INDUSTRIAL SECTOR*
Perlombongan	4,619.1	4,009.2	4,223.0	5,079.5	6,742.3	8,868.0	4,619.1	4,613.6	4,765.4	4,941.9	4,905.0	4,773.7	*Mining*
Pembuatan	1,589.5	1,578.1	1,641.0	1;749.7	1,768.0	1,952.5	1,589.4	1,591.6	1,700.6	1,751.3	1,731.6	1,697.7	*Manufacturing*
Pembinaan	305.8	360.9	390.7	401.1	422.8	418.5	305.8	361.7	395.3	406.9	424.0	457.8	*Construction*
Elektrik & Air	72.9	77.3	92.3	98.0	95.3	113.3	72.9	75.0	79.1	82.1	82.4	85.8	*Electricity & Water*
SEKTOR PERKHIDMATAN	3,652.8	3,896.0	4,001.4	3,956.2	4,127.4	4,361.5	3,652.8	3,875.7	3,983.0	4,048.6	4,129.4	4,299.7	*SERVICES SECTOR*
Pengangkutan & Perhubungan	393.5	407.1	425.3	444.9	453.7	456.4	393.5	401.6	427.2	435.8	419.9	437.4	*Transport & Communication*
Perdagangan	371.4	388.2	403.4	414.5	443.6	457.8	371.4	387.4	435.2	461.4	475.7	486.3	*Trade*
Kewangan	322.7	347.8	352.2	355.1	375.4	472.3	322.7	352.0	350.3	361.0	379.8	417.4	*Finance*
Hartanah & Pemilikan Tempat Kediaman	389.8	395.6	406.4	395.0	413.8	412.1	389.8	393.9	404.8	400.5	401.7	406.7	*Real Estate & Ownership of Dwellings*
Perkhidmatan Persendirian	589.1	647.7	703.9	657.8	655.5	715.9	589.1	649.7	645.2	677.7	686.4	735.5	*Private Services*
Perkhidmatan Kerajaan	1,586.2	1,709.6	1,710.2	1,688.9	1,785.3	1,847.0	1,586.2	1,691.0	1,720.4	1,712.2	1,766.0	1,816.5	*Government Services*
KELUARAN DALAM NEGERI KASAR (KDNK)	10,346.0	10,035.5	10,463.1	11,424.2	13,305.8	15,864.1	10,346.0	10,630.0	11,041.5	11,362.1	11,419.4	11,463.7	*GROSS DOMESTIC PRODUCT (GDP)*

Source: Brunei Darussalam Long-Term Development

Appendix A3 – Percent Distribution of Gross Domestic Product by Kind of Economic Activity at Current and Constant prices, 2000 – 2005 Brunei Darussalam

Jenis Aktiviti Ekonomi	Peratus Agihan (%) / *Per cent Distribution (%)*												*Kind of Economic Activity*
	Pada Harga Semasa *(At Current Prices)*						Pada Harga Tetap *(At Constant Prices)*						
	2000	2001	2002	2003	2004^r	2005^p	2000	2001	2002	2003	2004^r	2005^p	
PERTANIAN, PERHUTANAN & PERIKANAN	1.0	1.1	1.1	1.2	1.1	0.9	1.0	1.1	1.1	1.2	1.3	1.3	*AGRICULTURE, FORESTRY & FISHERY*
SEKTOR INDUSTRI	**63.7**	**60.0**	**60.7**	**64.1**	**67.9**	**71.6**	**63.7**	**62.5**	**62.9**	**63.2**	**62.6**	**61.2**	***INDUSTRIAL SECTOR***
Perlombongan	44.6	40.0	40.4	44.5	50.7	55.9	44.6	43.4	43.2	43.5	43.0	41.6	*Mining*
Pembuatan	15.4	15.7	15.7	15.3	13.3	12.3	15.4	15.0	15.4	15.4	15.2	14.8	*Manufacturing*
Pembinaan	3.0	3.6	3.7	3.5	3.2	2.6	3.0	3.4	3.6	3.6	3.7	4.0	*Construction*
Elektrik & Air	0.7	0.8	0.9	0.9	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	*Electricity & Water*
SEKTOR PERKHIDMATAN	**35.3**	**38.8**	**38.2**	**34.6**	**31.0**	**27.5**	**35.3**	**36.5**	**36.1**	**35.6**	**36.2**	**37.5**	***SERVICES SECTOR***
Pengangkutan & Perhubungan	3.8	4.1	4.1	3.9	3.4	2.9	3.8	3.8	3.9	3.8	3.7	3.8	*Transport & Communication*
Perdagangan	3.6	3.9	3.9	3.6	3.3	2.9	3.6	3.6	3.9	4.1	4.2	4.2	*Trade*
Kewangan	3.1	3.5	3.4	3.1	2.8	3.0	3.1	3.3	3.2	3.2	3.3	3.6	*Finance*
Hartanah & Pemilikan Tempat Kediaman	3.8	3.9	3.9	3.5	3.1	2.6	3.8	3.7	3.7	3.5	3.5	3.5	*Real Estate & Ownership of Dwellings*
Perkhidmatan Persendirian	5.7	6.5	6.7	5.8	4.9	4.5	5.7	6.1	5.8	6.0	6.0	6.4	*Private Services*
Perkhidmatan Kerajaan	15.3	17.0	16.3	14.8	13.4	11.6	15.3	15.9	15.6	15.1	15.5	15.8	*Government Services*
KELUARAN DALAM NEGERI KASAR (KDNK)	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	***GROSS DOMESTIC PRODUCT (GDP)***

Source: Brunei Darussalam Long-Term Development

APPENDIX B

Appendix B1 – t Test Owners and Contractors- Success Factors

	GROUP	N	Mean	Std D	t	Sig.(p)
S1	Owners	30	4.0333	.96431	.540	.591
	Contractors	33	3.8788	1.26880		
S2	Owners	30	3.9333	.94443	.720	.474
	Contractors	33	3.7273	1.28142		
S3	Owners	30	3.4333	1.33089	-1.360	.179
	Contractors	33	3.8788	1.26880		
S4	Owners	30	3.9667	.88992	-.434	.666
	Contractors	33	4.0606	.82687		
S5	Owners	30	3.9333	.94443	-.617	.540
	Contractors	33	4.0909	1.07132		
S6	Owners	30	3.6000	1.19193	.901	.371
	Contractors	33	3.3030	1.40278		
S7	Owners	30	3.9333	.94442	1.598	.115
	Contractors	33	3.4545	1.37138		

S1 : Organisational planning
S2 : Project manager's goal commitment
S3 : Project team's motivation and goal orientation
S4 : Clarity of the project scope and work definition
S5 : Project manager's capabilities and experience
S6 : Safety precautions and applied procedures
S7 : Use of control system

Appendix B2 – t Test Owners and Contractors –Delay Factors

	GROUP	N	Mean	Std D	t	Sig.(p)
D1	Owners	30	3.2667	1.47401	.522	.603
	Contractors	33	3.4545	1.37138		
D2	Owners	30	3.9667	.88992	**2.080**	**.042**
	Contractors	33	3.3636	1.34206		
D3	Owners	30	3.6667	1.24106	1.865	.067
	Contractors	33	3.0303	1.44665		
D4	Owners	30	4.0333	.96431	1.637	.107
	Contractors	33	3.5455	1.34840		
D5	Owners	30	3.2667	1.48401	.968	.336
	Contractors	33	2.9091	1.44403		
D6	Owners	30	3.3333	1.47001	**-2.481**	**.016**
	Contractors	33	4.0909	.91391		
D7	Owners	30	3.6333	1.29943	.530	.598
	Contractors	33	3.4545	1.37138		

D1 : Lack of communication between parties
D2: Slow decision making
D3 : Change orders
D4 : Inadequate contractor planning
D5 : Finance and payment of completed work
D6 : Subcontractors
D7 : Inadequate contractor experience

Appendix B3 – t Test Owners and Engineers – Success Factors

	GROUP	N	Mean	Std D	t	Sig.(p)
S1	Owners	30	4.0333	.96431	.036	.972
	Engineers	40	4.0250	.97369		
S2	Owners	30	3.9333	.94443	**3.127**	**.003**
	Engineers	40	3.0000	1.41421		
S3	Owners	30	3.4333	1.33089	-.980	.331
	Engineers	40	3.7250	1.15442		
S4	Owners	30	3.9667	.88992	**2.600**	**.011**
	Engineers	40	3.2000	1.41784		
S5	Owners	30	3.9333	.94443	.241	.810
	Engineers	40	3.8750	1.04237		
S6	Owners	30	3.6000	1.19193	**2.836**	**.006**
	Engineers	40	2.6750	1.45686		
S7	Owners	30	3.9333	.94442	1.439	.155
	Engineers	40	3.5250	1.32021		

Appendix B4 – t Test Owners and Engineers –Delay Factors

	GROUP	N	Mean	Std D	t	Sig.(p)
D1	Owners	30	3.2667	1.47401	1.345	.183
	Engineers	40	2.8000	1.39963		
D2	Owners	30	3.9667	.88992	**3.844**	**.000**
	Engineers	40	2.8000	1.47109		
D3	Owners	30	3.6667	1.24106	**2.367**	**.021**
	Engineers	40	2.9000	1.41058		
D4	Owners	30	4.0333	.96431	**4.267**	**.000**
	Engineers	40	2.8000	.32355		
D5	Owners	30	3.2667	1.48401	1.068	.289
	Engineers	40	2.9000	1.3735		
D6	Owners	30	3.3333	1.47001	1.035	.304
	Engineers	40	2.9750	1.40489		
D7	Owners	30	3.6333	1.29943	.898	.372
	Engineers	40	3.3500	1.31168		

Appendix B5 – t Test Contractor and Engineer- Success Factors

	GROUP	N	Mean	Std D	t	Sig.(p)
S1	Contractors	33	3.8788	1.26880	-.557	.579
	Engineers	40	4.0250	.97369		
S2	Contractors	33	3.7273	1.28142	**2.281**	**.026**
	Engineers	40	3.0000	1.41421		
S3	Contractors	33	3.8788	1.26880	.542	.590
	Engineers	40	3.7250	1.15442		
S4	Contractors	33	4.0606	.82687	**3.079**	**.003**
	Engineers	40	3.2000	1.41784		
S5	Contractors	33	4.0909	1.07132	.870	.387
	Engineers	40	3.8750	1.04237		
S6	Contractors	33	3.3030	1.40278	1.864	.066
	Engineers	40	2.6750	1.45686		
S7	Contractors	33	3.4545	1.37138	-.223	.824
	Engineers	40	3.5250	1.32021		

Appendix B6 – t Test Contractors and Engineers –Delay Factors

	GROUP	N	Mean	Std D	t	Sig.(p)
D1	Contractors	33	3.4545	1.37138	2.007	.049
	Engineers	40	2.8000	1.39963		
D2	Contractors	33	3.3636	1.34206	1.695	.095
	Engineers	40	2.8000	1.47109		
D3	Contractors	33	3.0303	1.44665	.388	.699
	Engineers	40	2.9000	1.41058		
D4	Contractors	33	3.5455	1.34840	**2.356**	**.021**
	Engineers	40	2.8000	.32355		
D5	Contractors	33	2.9091	1.44403	.027	.975
	Engineers	40	2.9000	1.3735		
D6	Contractors	33	4.0909	.91391	**3.926**	**.000**
	Engineers	40	2.9750	1.40489		
D7	Contractors	33	3.4545	1.37138	.332	.741
	Engineers	40	3.3500	1.31168		

APPENDIX C t Test – CSF's on CDF's

Appendix C1 – Owners and Contractors t Test – CSF's on CDF's

DELAY 1						
OCD1SF		N	Mean	St.D	t	Sig
S1D1	O	17	3.5882	1.50245	-.088	.931
	C	19	3.6316	1.46099		
S2D1	O	17	3.0588	1.34493	-.556	.582
	C	19	3.3158	1.41628		
S3D1	O	17	2.5882	1.32565	-1.696	.099
	C	19	3.3684	1.42246		
S4D1	O	17	3.1765	1.50977	-.583	.564
	C	19	3.4737	1.54087		
S5D1	O	17	4.9588	1.29762	.811	.423
	C	19	3.6842	1.45498		
S6D1	O	17	2.6471	1.53872	-.632	.531
	C	19	2.8474	1.31122		
S7D1	O	17	3.3529	1.32009	-.035	.972
	C	19	3.3684	1.34208		
O: Owners, C: contractors CSF: critical success factors CDF : critical delay factors S!D!: influence of success factor 1 on delay factor 1 and so on for all success factors on each delay factor						

DELAY 2						
OCD2SF		N	Mean	St.D	t	Sig
S1D2	O	17	3.2353	1.34766	-1.607	.116
	C	27	3.9259	1.41220		
S2D2	O	17	3.1765	1.23669	-.816	,419
	C	27	3.4815	1.18874		
S3D2	O	17	2.8824	1.26897	-1.022	.313
	C	27	3.2222	.93370		
S4D2	O	17	3.2941	1.15999	-1.386	.173
	C	27	3.8519	1.37851		
S5D2	O	17	3.9412	1,24853	-1.447	.155
	C	27	4.4074	.88835		
S6D2	O	17	2.7647	1.09141	-.046	.964
	C	27	2.7778	.80064		
S7D2	O	17	2.7647	1.09141	-2.577	.014
	C	27	3.6296	1.07946		

DELAY 3						
OCD3SF		N	Mean	St.D	t	Sig
S1D3	O	15	3.4000	1.35225	-2.010	.053
	C	20	4.2000	1.00525		
S2D3	O	15	2.9333	1.27988	-2.420	.021
	C	20	4.0000	1.29777		
S3D3	O	15	3.1333	1.30201	-1.474	.150
	C	20	3.7500	1.16416		
S4D3	O	15	3.4000	1.35225	-.821	.417
	C	20	3.7500	1.16416		
S5D3	O	15	3.4667	1.45733	-2.138	.040
	C	20	4.3500	.98809		
S6D3	O	15	2.7333	1.22280	-.701	.488
	C	20	3.0000	1.02598		
S7D3	O	15	3.2000	1.32017	-1.859	.072
	C	20	4.0000	1.21395		

DELAY 4						
OCD4SF		N	Mean	St.D	t	Sig
S1D4	O	18	3.6111	1.46082	-.1460	.153
	C	20	4.2000	1.00525		
S2D4	O	18	3.2222	1.47750	-1.728	.093
	C	20	4.0000	1.29777		
S3D4	O	18	3.2778	1.44733	-1.113	.273
	C	20	3.7500	1.16416		
S4D4	O	18	3.5000	1.46528	-.585	.562
	C	20	3.7500	1.16416		
S5D4	O	18	3.0000	1.49509	-3.315	.002
	C	20	4.3500	.98809		
S6D4	O	18	3.0000	1.49509	.000	1.00
	C	20	3.0000	1.02598		
S7D4	O	18	3.7222	1.27443	-.688	.496
	C	20	4.0000	1.21395		

DELAY 5						
OCD5SF		N	Mean	St.D	t	Sig
S1D5	O	16	3.1250	1.50245	-.863	.332
	C	20	3.6000	1.46099		
S2D5	O	16	3.0000	1.41421	-.939	.354
	C	20	3.4000	1.14248		
S3D5	O	16	2.9375	1.52616	-.675	.504
	C	20	3.2500	1.25132		
S4D5	O	16	3.3750	1.36015	-.176	.861
	C	20	3.4500	1.19087		
S5D5	O	16	3.6250	1.36015	-1.809	,284
	C	20	4.1000	1.25237		
S6D5	O	16	2.7500	1.39044	.000	1.00
	C	20	2.7500	1.25132		
S7D5	O		3.0000	1.41421	-1.687	.099
	C		3.8000	1.39925		

DELAY 6						
OCD6SF		N	Mean	St.D	t	Sig
S1D6	O	14	3.0000	1.35873	-3.440	.002
	C	19	4.4211	1.01739		
S2D6	O	14	3.0714	1.32806	-2.806	.009
	C	19	4.1579	.89834		
S3D6	O	14	2.9286	1.26881	-.899	.376
	C	19	3.2632	.87191		
S4D6	O	14	3.2143	1.42389	-2.333	.026
	C	19	4.1579	.89834		
S5D6	O	14	3.0714	1.32806	-3.550	.001
	C	19	4.3684	.76089		
S6D6	O	14	2.7143	1.38278	-.674	.505
	C	19	3.0000	1.05409		
S7D6	O	14	2.6429	1.27745	-3.615	.001
	C	19	4.0000	.88192		

DELAY 7						
OCD7SF		N	Mean	St.D	t	Sig
S1D7	O	17	3.5882	1.27764	-2.873	.006
	C	15	4.6667	.62721		
S2D7	O	17	2.9412	1.51948	-1.668	.106
	C	15	3.8000	1.37321		
S3D7	O	17	3.5294	1.32842	.547	.588
	C	15	3.2667	1.38701		
S4D7	O	17	3.5294	1.46277	-.673	.506
	C	15	3.8667	1.35576		
S5D7	O	17	3.7647	1.25147	-2.312	.028
	C	15	4.6667	.89974		
S6D7	O	17	2.7059	1.35852	.406	.688
	C	15	2.5333	.99043		
S7D7	O	17	3.4118	1.32565	-1.915	.065
	C	15	4.2000	.94112		

Appendix C2 – Contractor and Engineers –t Test CSF's on CDF's

DELAY 1						
CED1SF		N	Mean	St.D	t	Sig
S1D1	C	19	3.6316	1.46099	-1.333	.189
	E	30	4.0667	.82768		
S2D1	C	19	3.3158	1.41628	-1.176	.246
	E	30	3.7000	.87691		
S3D1	C	19	3.3684	1.42246	.005	.996
	E	30	3.3667	.92786		
S4D1	C	19	3.4737	1.54087	-3.937	.000
	E	30	4.7000	.59596		
S5D1	C	19	3.6842	1.45498	-3.414	.001
	E	30	4.7000	.59596		
S6D1	C	19	2.9474	1.31122	-.608	.546
	E	30	3.1667	1.17688		
S7D1	C	19	3.3684	1.34208	-1.048	.300
	E	30	3.7000	.87691		
E: engineers, C: contractors CSF: critical success factors CDF : critical delay factors S!D!: influence of success factor 1 on delay factor 1 and so on for all success factors on each delay factor						

DELAY 2						
CED2SF		N	Mean	St.D	t	Sig
S1D1	C	27	3.9259	1.41220	-.803	.425
	E	38	4.1579	.91611		
S2D1	C	27	3.4815	1.18874	-1.390	.170
	E	38	3.9211	1.30242		
S3D1	C	27	3.2222	.93370	.034	.973
	E	38	3.2105	1.59658		
S4D1	C	27	3.8519	1.37851	-1.076	.286
	E	38	4.1579	.91611		
S5D1	C	27	4.4074	.88835	1.096	.277
	E	38	4.1579	.91611		
S6D1	C	27	2.7778	.80064	-1.157	.252
	E	38	3.1316	1.43642		
S7D1	C	27	3.6296	1.07946	-.168	.867
	E	38	3.6842	1.41622		

DELAY 3						
CED3SF		N	Mean	St.D	t	Sig
S1D1	C	20	4.2000	1.00525	-1.613	.113
	E	32	4.5625	.61892		
S2D1	C	20	4.0000	1.29777	-.262	.794
	E	32	4.0938	1.22762		
S3D1	C	20	3.7500	1.16416	1.647	.106
	E	32	3.1563	1.32249		
S4D1	C	20	3.7500	1.16416	-.972	.336
	E	32	4.0625	1.10534		
S5D1	C	20	4.3500	. .98809	-.101	.920
	E	32	4.3750	.79312		
S6D1	C	20	3.0000	1.02598	-1.762	.084
	E	32	3.5313	1.07716		
S7D1	C	20	4.0000	1.21395	-1.715	.093
	E	32	4.4688	.76134		

DELAY 4						
CED4SF		N	Mean	St.D	t	Sig
S1D1	C	20	4.2000	1.00525	2.275	.027
	E	32	3.4063	1.34066		
S2D1	C	20	4.0000	1.29777	-.729	.470
	E	32	4.2188	.87009		
S3D1	C	20	3.7500	1.16416	2.729	.009
	E	32	2.8125	1.22967		
S4D1	C	20	3.7500	1.16416	2.729	.009
	E	32	2.8125	1.22967		
S5D1	C	20	4.3500	.98809	.244	.809
	E	32	4.2813	.99139		
S6D1	C	20	3.0000	1.02598	-4.307	.000
	E	32	4.2813	1.05446		

DELAY 5						
CED5SF		N	Mean	St.D	t	Sig
S1D1	C	20	3.6000	1.39170	.897	.373
	E	36	3.2222	1.56955		
S2D1	C	20	3.4000	1.14248	.820	.416
	E	36	3.0833	1.50000		
S3D1	C	20	3.2500	1.25132	..850	.399
	E	36	2.9400	1.30809		
S4D1	C	20	3.4500	1.19097	-.636	.528
	E	36	3.6944	1.47007		
S5D1	C	20	4.1000	1.25237	-.782	.438
	E	36	4.3333	.95618		
S6D1	C	20	2.7500	1.25132	-.293	.771
	E	36	2.8611	1.41730		
S7D1	C	20	3.8000	1.39925	.339	.736
	E	36	3.6667	1.41421		

DELAY 6						
CED6SF		N	Mean	St.D	t	Sig
S1D1	C	19	4.4211	1.01739	.832	.409
	E	36	4.1667	1.10841		
S2D1	C	19	4.1579	.89834	1.129	.264
	E	36	3.8056	1.19090		
S3D1	C	19	3.2632	.87191	1.430	.159
	E	36	2.7778	1.33333		
S4D1	C	19	4.1579	.89834	1.856	.069
	E	36	3.5556	1.25230		
S5D1	C	19	4.3684	.76089	1.154	.254
	E	36	4.0278	1.15847		
S6D1	C	19	3.0000	1.05409	.622	.537
	E	36	2.7778	1.35459		
S7D1	C	19	4.0000	.88192	.940	.351
	E	36	3.6944	1.26083		

DELAY 7						
CED7SF		N	Mean	St.D	t	Sig
S1D1	C	15	4.6667	.61721	1.237	.222
	E	36	4.3611	.86694		
S2D1	C	15	3.8000	1.37321	.296	.769
	E	36	3.6944	1.06421		
S3D1	C	15	3.2667	1.38701	-2.104	.041
	E	36	4.0278	1.08196		
S4D1	C	15	3.8667	1.35576	-.762	.456
	E	36	4.1389	1.09942		
S5D1	C	15	4.6667	.89974	1.285	.205
	E	36	4.3056	.92023		
S6D1	C	15	2.5333	.99043	-2.923	.005
	E	36	3.5000	1.10841		
S7D1	C	15	4.2000	.94112	-.575	.568
	E	36	4.3611	.89929		

Appendix C3 – Owner and Engineer –t Test CSF's on CDF's

DELAY 1						
OED1SF		N	Mean	St.D	t	Sig
S1D1	O	19	3.6316	1.46099	-1.333	.189
	E	30	4.0667	.82768		
S2D1	O	19	3.3158	1.41628	-1.176	.246
	E	30	3.7000	.87691		
S3D1	O	19	3.3684	1.42246	.005	.996
	E	30	3.3667	.92786		
S4D1	O	19	3.4737	1.54087	-3.937	.000
	E	30	4.7000	.59596		
S5D1	O	19	3.6842	1.45498	-3.414	.001
	E	30	4.7000	.59596		
S6D1	O	19	2.9474	1.31122	-.608	.546
	E	30	3.1667	1.17688		
S7D1	O	19	3.3684	1.34208	-1.048	.300
	E	30	3.7000	.87691		

O: Owners, E: engineers
CSF: critical success factors
CDF : critical delay factors
S!D!: influence of success factor 1 on delay factor 1 and so on for all success factors on each delay factor

DELAY 2						
OED2SF		N	Mean	St.D	t	Sig
S1D1	O	17	3.2353	1.34766	-2.969	.004
	E	38	4.1579	.91611		
S2D1	O	17	3.1762	1.23669	-1.989	.052
	E	38	3.9211	1.30242		
S3D1	O	17	2.8824	1.26897	-.747	.458
	E	38	3.2105	1.59658		
S4D1	O	17	3.2941	1.15999	-2.972	.004
	E	38	4.1579	.91611		
S5D1	O	17	3.9412	1.15999	-.723	.473
	E	38	4.1579	.91611		
S6D1	O	17	2.7647	1.09141	- .937	.353
	E	38	3.1316	1.43642		
S7D1	O	17	2.7647	1.09141	-2.376	.021
	E	38	3.6842	1.41622		

DELAY 3						
OED3SF		N	Mean	St.D	t	Sig
S1D1	O	17	3.2353	1.34766	-4.739	.000
	E	32	4.5625	.61892		
S2D1	O	17	3.1765	1.23669	-2.483	.017
	E	32	4.0938	1.22762		
S3D1	O	17	2.8824	1.26897	-.700	.488
	E	32	3.1563	1.32249		
S4D1	O	17	3.2941	1.15999	-2.277	.027
	E	32	4.0625	1.10534		
S5D1	O	17	3.9412	1.24853	-1.487	.144
	E	32	4.3750	.79312		
S6D1	O	17	2.7647	1.09141	-2.360	.022
	E	32	3.5313	1.07716		
S7D1	O	17	2.7647	1.09141	-6.397	.000
	E	32	4.4688	.76134		

DELAY 4						
OED4SF		N	Mean	St.D	t	Sig
S1D1	O	17	3.2353	1.34766	-.424	.673
	E	32	3.4063	1.34066		
S2D1	O	17	3.1765	1.23669	-3.439	.001
	E	32	4.2188	.87009		
S3D1	O	17	2.8824	1.26897	.187	.852
	E	32	2.8125	1.22967		
S4D1	O	17	3.2941	1.15999	1.330	.190
	E	32	2.8125	1.22967		
S5D1	O	17	3.9412	124853	-1.044	.302
	E	32	4.2813	.99139		
S6D1	O	17	2.7647	1.09141	-4.735	.000
	E	32	4.2813	1.05446		
S7D1	O	17	2.7647	1.09141	-2.925	.005
	E	32	3.7188	1.08462		

DELAY 5						
OED5SF		N	Mean	St.D	t	Sig
S1D1	O	17	3.2353	1.34766	.030	.977
	E	36	3.2222	1.56955		
S2D1	O	17	3.1765	1.23669	.222	.825
	E	36	3.0833	1.50000		
S3D1	O	17	2.8824	1.26897	-.163	.871
	E	36	2.9444	1.30809		
S4D1	O	17	3.2941	1.15999	-.986	.329
	E	36	3.6944	1.47007		
S5D1	O	17	3.9412	1.24853	-1.261	.213
	E	36	4.3333	.95618		
S6D1	O	17	2.7647	1.09141	-.247	.806
	E	36	2.8611	1.41730		
S7D1	O	17	2.7647	1.09141	-2.319	.024
	E	36	3.6667	1.41421		

DELAY 6						
OED6SF		N	Mean	St.D	t	Sig
S1D1	O	17	3.2353	1.34766	-2.663	.010
	E	36	4.1667	1.10841		
S2D1	O	17	3.1765	1.23669	-1.773	.082
	E	36	3.8056	1.19090		
S3D1	O	17	2.8824	1.26897	.271	.788
	E	36	2.7778	1.33333		
S4D1	O	17	3.2941	1.15999	-.726	.471
	E	36	3.5556	1.25230		
S5D1	O	17	3.9412	1.24853	-.248	.805
	E	36	4.0278	1.15847		
S6D1	O	17	2.7647	1.09141	-.035	.972
	E	36	2.7778	1.35459		
S7D1	O	17	2.7647	1.09141	-2.611	.012
	E	36	3.6944	1.26083		

DELAY7						
OED7SF		N	Mean	St.D	t	Sig
S1D1	O	17	3.2353	1.34766	-3.672	.001
	E	36	4.3611	.86694		
S2D1	O	17	3.1765	1.23669	-1.570	.123
	E	36	3.6944	1.06421		
S3D1	O	17	2.8824	1.26897	-3.403	.001
	E	36	4.0278	1.08196		
S4D1	O	17	3.2941	1.15999	-2.566	.013
	E	36	4.1389	1.09942		
S5D1	O	17	3.9412	1.24853	-1.197	.237
	E	36	4.3056	.92023		
S6D1	O	17	2.7647	1.09141	-2.265	.028
	E	36	3.5000	1.10841		
S7D1	O	17	2.7647	1.09141	-5.629	.000
	E	36	4.3611	.89929		

APPENDIX D – ONE-WAY ANOVA RESULT

Appendix D1 – One-Way ANOVA Results for Owners

Delay 1							Delay 2					
	Mean	St.D	n	Sort	R			Mean	St,D	n	Sort	R
S1	3.6316	1.46099	19	3.6842	5		S1	3.2353	1.34766	17	3.9412	5
S2	3.3158	1.41628	19	3.6316	1		S2	3.1765	1.23669	17	3.2941	4
S3	3.3684	1.42246	19	3.4737	4		S3	2.8824	1.26897	17	3.2353	1
S4	3.4737	1.54087	19	3.3684	7		S4	3.2941	1.15999	17	3.1765	2
S5	3.6842	1.45498	19	3.3684	3		S5	3.9412	1.24853	17	2.9412	7
S6	2.9474	1.31122	19	3.3158	2		S6	2.7647	1.09141	17	2.8824	3
S7	3.3684	1.34208	19	2.9474	6		S7	2.9412	1.29762	17	2.7647	6
Delay 3							**Delay 4**					
	Mean	St.D	n	Sort	R			Mean	St.D	n	Sort	R
S1	3.4000	1.35225	15	3.4667	5		S1	3.6111	1.46082	18	3.7222	7
S2	2.9333	1.27988	15	3.4000	1		S2	3.2222	1.47750	18	3.6111	1
S3	3.1333	1.30201	15	3.4000	4		S3	3.2778	1.44733	18	3.5000	6
S4	3.4000	1.35225	15	3.2000	7		S4	3.5000	1.46528	18	3.2778	3
S5	3.4667	1.45733	15	3.1333	3		S5	3.0000	1.49509	18	3.2222	2
S6	2.7333	1.22280	15	2.9333	2		S6	3.0000	1.49509	18	3.0000	5
S7	3.2000	1.32017	15	2.7333	6		S7	3.7222	1.27443	18	3.0000	6
Delay 5							**Delay 6**					
	Mean	St.D	n	Sort	R			Mean	St.D	n	Sort	R
S1	3.1250	1.50000	16	3.6250	5		S1	3.0000	1.35873	14	3.2143	4
S2	3.0000	1.41421	16	3.3750	4		S2	3.0714	1.32806	14	3.0714	2
S3	2.9375	1.52616	16	3.1250	1		S3	2.9286	1.26881	14	3.0714	5
S4	3.3750	1.36015	16	3.0000	2		S4	3.2143	1.42389	14	3.0000	1
S5	3.6250	1.36015	16	3.0000	7		S5	3.0714	1.32806	14	2.9286	3
S6	2.7500	1.41412	16	2.9375	3		S6	2.7143	1.38278	14	2.7143	6
S7	3.0000	1.41259	16	2.7500	6		S7	2.6429	1.27745	14	2.6429	7
Delay 7												
	Mean	St.D	n	Sort	R							
S1	3.5882	1.27764	17	3.7647	5							
S2	2.9412	1.51948	17	3.5882	1							
S3	3.5294	1.32842	17	3.5294	3							
S4	3.5294	1.46277	17	3.5294	4							
S5	3.7647	1.25147	17	3.4118	7							
S6	2.7059	1.35852	17	2.9412	2							
S7	3.4118	1.32565	17	2.7059	6							

Appendix D2 – One-Way ANOVA Summary Results for Owners

	D1	D2	D3	D4	D5	D6	D7
	Highest						
S	5	5**	5	7	5	4	5
S	1	4	1	1	4	2	1
S	4	1	4	6	1	5	3
S	7	2	7	3	2	1	4
S	3	7	3	2	7	3	7
S	2	3*	2	5	3	6	2
S	6	6	6	6	6	7	6
	Least						

S1 : Organisation planning effort S2 : Project manager's goal commitment S3 : Project team's motivation and goal orientation S4 :Clarity of project scope and definition S5 : Project manager's capability and experience S6 : Safety precautions and applied procedures S7 : Use of control system	D1 : Lack of communication between parties D2 : Slow decision making D3 : Change orders D4 : Contractor's inadequate planning D5 : Finance and payment of completed work D6 : Subcontractors D7 : Inadequate contractor experience

Appendix D3 – One-Way ANOVA Results for Owners (Post – Hoc)

Delay	(I) Success Factor	(J) Success Factor	Mean Difference (I – J)	(p)
D2	3	5	-1.05882	.014
	5	6	1.17647	.007
	5	7	1.00000	.020
D7	5	6	1.05882	.026
*The mean difference is significant at the 0.05 level				

Appendix D4 – One-Way ANOVA Results for Contractors

Delay 1							Delay 2					
	Mean	St.D	n	Sort	R			Mean	St,D	n	Sort	R
S1	3.9259	1.4122.	27	4.4074	5		S1	3.9259	1.41220	27	4.4074	5
S2	3.4815	1.18874	27	3.9259	1		S2	3.4815	1.18874	27	3.9259	1
S3	3.2222	.93370	27	3.8519	4		S3	3.2222	.93370	27	3.8519	4
S4	3.8519	1.37851	27	3.6296	7		S4	3.8519	1.37851	27	3.6296	7
S5	4.4074	.88835	27	3.4815	2		S5	4.4074	.88835	27	3.4815	2
S6	2.7778	80064	27	3.2222	3		S6	2.7778	.80064	27	3.2222	3
S7	3.6296	1.07946	27	2.7778	6		S7	3.6296	1.07946	27	2.7778	6
Delay 3							**Delay 4**					
	Mean	St.D	n	Sort	R			Mean	St.D	n	Sort	R
S1	4.2000	1.00525	20	4.3500	5		S1	4.1250	.95743	16	4.2500	5
S2	4.0000	1.29777	20	4.2000	1		S2	3.0625	1.38894	16	4.1250	1
S3	3.7500	1.16416	20	4.0000	2		S3	3.1250	1.31022	16	3.8125	7
S4	3.7500	1.16416	20	4.0000	7		S4	3.6875	1.01448	16	3.6875	4
S5	4.3500	.98809	20	3.7500	4		S5	4.2500	1.12546	16	3.1250	3
S6	3.0000	1.02598	20	3.7500	3		S6	2.6250	.95743	16	3.0625	2
S7	4.0000	1.21395	20	3.0000	6		S7	3.8125	.91059	16	2.6250	6
Delay 5							**Delay 6**					
	Mean	St.D	n	Sort	R			Mean	St.D	n	Sort	R
S1	3.6000	1.39170	20	4.1000	5		S1	4.4211	1.01739	19	4.4211	1
S2	3.4000	1.14248	20	3.8000	7		S2	4.1579	.89834	19	4.3684	5
S3	3.2500	1.25132	20	3.6000	1		S3	3.2632	.87191	19	4.1579	2
S4	3.4500	1.19097	20	3.4500	4		S4	4.1579	.89834	19	4.1579	4
S5	4.1000	1.25237	20	3.4000	2		S5	4.3684	.76089	19	4.0000	7
S6	2.7500	1.25132	20	3.2500	3		S6	3.0000	1.05409	19	3.2632	3
S7	3.8000	1.39925	20	2.7500	6		S7	4.0000	.88192	19	3.0000	6
Delay 7												
	Mean	St.D	n	Sort	R							
S1	4.6667	.61721	15	4.6667	1							
S2	3.8000	1.37321	15	4.6667	5							
S3	3.2667	1.38701	15	4.2000	7							
S4	3.8667	1.35576	15	3.8667	4							
S5	4.6667	.89974	15	3.8000	2							
S6	2.5333	.99043	15	3.2667	3							
S7	4.2000	.94112	15	2.5333	6							

Appendix D5 – One-Way ANOVA Summary Results for Contractors

	D1	D2	D3	D4	D5	D6	D7
	Highest						
S		5	5	5	5	1	1
S		1	1	1	7	5	5
S		4	2	7	1	2	7
S		7	7	4	4	4	4
S		2	4	3	2	7	2
S		3	3	2	3	3	3
S		6	6	6	6	6	6
	Least						
S1 : Organisation planning effort S2 : Project manager's goal commitment S3 : Project team's motivation and goal orientation S4 :Clarity of project scope and definition S5 : Project manager's capability and experience S6 : Safety precautions and applied procedures S7 : Use of control system			D1 : Lack of communication between parties D2 : Slow decision making D3 : Change orders D4 : Contractor's inadequate planning D5 : Finance and payment of completed work D6 : Subcontractors D7 : Inadequate contractor experience				

Appendix D6 – One-Way ANOVA Results for Contractors (Post – Hoc)

Delay	(I) Success Factor	(J) Success Factor	Mean Difference (I – J)	(p)
D1	1	3	1.00000	.043
	3	5	-1.23529	.013
	5	6	1.17647	.018
D2	1	3	.70370	.022
	1	6	1.14815	.000
	2	5	- .92593	.003
	2	6	.70370	.022
	3	4	-.62963	.040
	4	6	1.07407	.001
	5	6	1.62963	.000
	5	7	.77778	.012
	6	7	- .85185	.006
D3	1	6	1.20000	.001
	2	6	1.00000	.006
	3	6	.75000	.037
	4	6	.75000	.037
	5	6	1.35000	.000
	6	7	-1.00000	.006
D4	1	2	1.06250	.008
	1	3	1.00000	.012
	1	6	1.500000	.000
	2	5	-1.18750	.003
	3	5	-1.23500	.005
	4	6	1.06250	.008

	5	6	1.62500	.000
	6	7	-1.18750	.003
D5	1	6	.85000	.036
	3	5	-.85000	.036
	5	6	1.35000	.001
	6	7	-1.50000	.010
*The mean difference is significant at the o,o5 level				

Appendix D7 – One-Way ANOVA Results for Engineers

Delay 1							**Delay 2**					
	Mean	St.D	n	Sort	R			Mean	St,D	n	Sort	R
S1	4.0667	.82768	30	4.7000	5		S1	4.1579	.91611	38	4.1579	1
S2	3.7000	.87691	30	4.3667	4		S2	3.9211	1.30242	38	4.1579	4
S3	3.3667	.92786	30	4.0667	1		S3	3.2015	1.59658	38	4.1579	5
S4	4.3667	.99943	30	3.7000	2		S4	4.1579	.91611	38	3.9211	2
S5	4.7000	.59596	30	3.7000	7		S5	4.1579	.91611	38	3.6842	7
S6	3.1667	1.17688	30	3.3667	3		S6	3.1316	1.43642	38	3.2015	3
S7	3.7000	.87691	30	3.1667	6		S7	3.6842	1.41622	38	3.1316	6
Delay 3							**Delay 4**					
	Mean	St.D	n	Sort	R			Mean	St.D	n	Sort	R
S1	4.5625	.61892	32	4.5625	1		S1	3.4063	1.34066	32	4.2813	5
S2	4.0938	1.22762	32	4.4688	7		S2	4.2188	.87009	32	4.2813	6
S3	3.1563	1.32249	32	4.3750	5		S3	2.8125	1.22967	32	4.2188	2
S4	4.0625	1.10534	32	4.0938	2		S4	2.8125	1.22967	32	3.7188	7
S5	4.3750	.79312	32	4.0625	4		S5	4.2813	.99139	32	3.4063	1
S6	3.5313	1.07716	32	3.5313	6		S6	4.2813	1.05446	32	2.8125	3
S7	4.4688	.76134	32	3.1563	3		S7	3.7188	1.08462	32	2.8125	4
Delay 5							**Delay 6**					
	Mean	St.D	n	Sort	R			Mean	St.D	n	Sort	R
S1	3.2222	1.56955	36	4.3333	5		S1	4.1667	1.10841	36	4.1667	1
S2	3.0833	1.50000	36	3.6944	4		S2	3.8056	1.19090	36	4.0278	5
S3	2.9444	1.30809	36	3.6667	7		S3	2.7778	1.33333	36	3.8056	2
S4	3.6944	1.47007	36	3.2222	1		S4	3.5556	1.25230	36	3.6944	7
S5	4.3333	.95618	36	3.0833	2		S5	4.0278	1.15847	36	3.5556	4
S6	2.8611	1.41730	36	2.9444	3		S6	2.7778	1.35459	36	2.7778	3
S7	3.6667	1.41421	36	2.8611	6		S7	3.6944	1.26083	36	2.7778	6

Delay 7							
	Mean	St.D	n	Sort	R		
S1	4.3611	.86694	36	4.3611	1		
S2	3.6944	1.06421	36	4.3611	7		
S3	4.0278	1.08196	36	4.3056	5		
S4	4.1389	1.09942	36	4.1389	4		
S5	4.3056	.92023	36	4.0278	3		
S6	3.5000	1.10841	36	3.6944	2		
S7	4.3611	.89929	36	3.5000	6		

Appendix D8 – One-Way ANOVA Summary Results for Engineers

	D1	D2	D3	D4	D5	D6	D7
	Highest						
S	5	1	1	5	5	1	1
S	4	4	7	6	4	5	7
S	1	5	5	2	7	2	5
S	2	2	2	7	1	7	4
S	7	7	4	1	2	4	3
S	3	3	6	3	3	3	2
S	6	6	3	4	6	6	6

S1 : Organisation planning effort S2 : Project manager's goal commitment S3 : Project team's motivation and goal orientation S4 :Clarity of project scope and definition S5 : Project manager's capability and experience S6 : Safety precautions and applied procedures S7 : Use of control system	D1 : Lack of communication between parties D2 : Slow decision making D3 : Change orders D4 : Inadequate contractor's planning D5 : Finance and payment of completed work D6 : Subcontractors D7 : Inadequate contractor experience

Appendix D9 – One-Way ANOVA Results for Engineers (Post – Hoc)

Delay	(I) Success Factor	(J) Success Factor	Mean Difference (I – J)	(p)
D1	1	3	.70000	.003
	1	5	-.63333	.008
	1	6	.90000	.000
	2	4	-.66667	.005
	2	5	-1.00000	.000
	2	6	.53333	.025
	3	4	-1.00000	.000
	3	5	-1.33333	.000
	4	6	1.20000	.000
	4	7	.66667	.005
	5	6	1.53333	.000
	5	7	1.00000	.000
	6	7	-.53333	.025
D2	1	3	.94737	.001
	1	6	1.02362	.000
	2	3	.71053	.013
	2	6	.78947	.006
	3	4	-.94737	.001
	3	5	-.94737	.001
	4	6	1.02632	.000
	5	6	1.02632	.000
D3	1	3	1.40625	.000
	1	6	1.03125	.000
	2	3	.93750	.000
	2	6	1.03125	.028
	3	4	-.90625	.000
	3	5	-1.21875	.000
	3	7	-.37500	.000
	4	6	.53125	.038
	5	6	.84375	.001
	6	7	-.93750	.000
D4	1	2	-.81250	.004
	1	3	.59375	.036
	1	4	.59375	.036
	1	5	-.87500	.002
	1	6	-.87500	.002

	2	3	1.40625	.000
	2	4	.59375	.036
	3	5	-1/46875	.000
	3	6	-1.46875	.000
	3	7	-.90625	.001
	4	5	-1.46875	.000
	4	6	-1.46875	.000
	4	7	-.90625	.001
	5	7	.56250	.047
	6	7	.56250	.047
D5	1	5	-1.11111	.001
	2	5	-1.25000	.000
	3	4	-.75000	.023.
	3	5	-1.38889	.000
	3	7	-.72222	.028
	4	6	.83333	.012
	5	6	1.47222	.000
	5	7	..6667	.043
	6	7	-.80556	.015
D6	1	3	1.38889	.000
	1	4	.61111	.038
	1	6	1.38889	.000
	2	3	1.02778	.001
	2	6	1.02778	.001
	3	4	-.77778	.008
	3	5	-1.25000	.000
	3	7	-.91667	.002
	4	6	.7778	.008
	5	6	1.25000	.000
	6	7	-.91667	.002
D7	1	2	.66667	.006
	1	6	.86111	.000
	2	5	-.61111	.000
	2	7	-.66667	.006
	3	6	.52778.	.028
	4	6	.63889	.008
	5	6	.80556	.001
	6	7	-.86111	.000
*The mean difference is significant at the 0.05 level				

APPENDIX E – TWO-WAY ANOVA

Appendix E1 – Two-way ANOVA-Owner and Contractor

Delay 1						
	Owner n = 19		Contractor n= 17		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.6316	1.46099	3.5882	1.50245	3.6099	5
2	3.3158	1.41628	3.0588	1.34493	3.1873	1
3	3.3684	1.42246	2.5882	1.32565	2.9783	4
4	3.4737	1.54087	3.4118	1.46026	3.4428	7
5	3.6842	1.45498	3.8235	1.46779	3.7539	2
6	2.9474	1.31122	2.6471	1.53872	2.7973	3
7	3.3684	1.34208	3.3529	1.32009	3.3607	6
M	3.3985		3.2101			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effext)						

Delay 2						
	Owner n = 17		Contractor n= 27		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.2353	1.34766	3.9259	1.41220	3.5806	5
2	3.1765	1.23669	3.4815	1.18874	3.3290	1
3	2.8824	1.26897	3.2222	.93370	3.0523	4
4	3.2941	1.15999	3.8519	1.37851	3.5730	2
5	3.9412	1.24853	4.4074	.88835	4.1743	7
6	2.7647	1.09141	2.7778	.80064	2.7713	3
7	2.9412	1.29762	3.6296	1.07946	3.2854	6
M	3.1765		3.6138			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Delay 3						
	Owner n =15		Contractor n= 20		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.4000	1.35225	4.2000	1.00525	3.8000	5
2	2.9333	1.27988	4.0000	1.29777	3.4667	1
3	3.1333	1.30201	3.7500	1.16416	3.4417	7
4	3.4000	1.35225	3.7500	1.16416	3.5750	4
5	3.4667	1.45733	4.3500	.98809	3.9084	2
6	2.7333	1.22280	3.0000	1.02598	2.8667	3
7	3.2000	1.32017	4.0000	1.21395	3.6000	6
M	3.1810		3.8643			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Delay 4						
	Owner n = 18		Contractor n= 16		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.6111	1.46082	4.1250	.95743	3.8681	1
2	3.2222	1.47750	3.0625	1.38894	3.1423	7
3	3.2778	1.44733	3.1250	1.31022	3.2014	5
4	3.5000	1.46528	3.6875	1.01448	3.5938	4
5	3.0000	1.49509	4.2500	1.12546	3.6250	3
6	3.0000	1.49509	2.6250	.95743	2.8125	2
7	3.7222	1.27443	3.8125	.91059	3.7674	6
M	3.3333		3.5268			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Delay 5						
	Owner n = 16		Contractor n= 20		Marginal mean owner + contractor)/2	Sorting Highest to lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.1250	1.50000	3.6000	1.39170	3.3625	5
2	3.0000	1.41421	3.4000	1.14248	3.2000	4
3	2.9375	1.52616	3.2500	1.25132	3.0938	7
4	3.3750	1.36015	3.4500	1.19097	3.4125	1
5	3.6250	1.36015	4.1000	1.25237	3.8625	2
6	2.7500	1.39044	2.7500	1.25132	2.7500	3
7	3.0000	1.41421	3.8000	1.39925	3.4000	6
M	3.1161		3.4786			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Delay 6						
	Owner n = 14		Contractor n=		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.0000	1.35873	4.4211	1.01739	3.7106	5
2	3.0714	1.32806	4.1579	.89834	3.6147	1
3	2.9286	1.26881	3.2632	.87191	3.0959	4
4	3.2143	1.42389	4.1579	.89834	3.6861	2
5	3.0714	1.32806	4.3684	.76089	3.7199	7
6	2.7143	1.38278	3.0000	1.05409	2.8572	3
7	2.6429	1.27745	4.0000	.88192	3.3215	6
M	2.9490		3.9098			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Delay 7						
	Owner n = 17		Contractor n= 15		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.5882	1.27764	4.6667	.61721	4.1275	5
2	2.9412	1.51948	3.8000	1.37321	3.3706	1
3	3.5294	1.32842	3.2667	1.38701	3.3981	7
4	3.5294	1.46277	3.8667	1.35576	3.6981	4
5	3.7647	1.25147	4.6667	.89974	4.2157	3
6	2.7059	1.35852	2.5333	.99043	2.6196	2
7	3.4118	1.32565	4.2000	.94112	3.8059	6
M	3.3529		3.8571			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Appendix E2 – Owners and Contractors – Main effects – Calculation

Delay 1					
Source	SS	d.f	MS	F	Sig (p)
SF	24.940	6	4.157	2.050	.060
SF X G	4.861	6	.810	.399	.879
Error	482.687	238	2.028		
Group	2.230	1	2.230	1.099	.295
Error					
SF: success factors, SFXG: Success factors by group(interaction, SS: Sum of squares, df: degree of freedom, MS: Mean square					

Delay 2					
Source	SS	d.f	MS	F	Sig (p)
SF	49.919	6	8.320	6.116	.111
SF X G	3.647	6	.608	.447	.009
Error	399.913	294	1.360		
Group	13.963	1	13.963	10.265	.002
Error					

Delay 3					
Source	SS	d.f	MS	F	Sig (p)
SF	23.122	6	3.854	2.602	.019
SF X G	4.314	6	.719	.485	.819
Error	342.183	231	1.481		
Group	28.017	1	28.017	18.913	.000
Error					

Delay 4					
Source	SS	d.f	MS	F	Sig (p)
SF	44.414	6	7.402	5.909	.000
SF X G	57.259	6	9.543	7.617	.000
Error	403.406	322	1.253		
Group	1.085	1	1.065	.866	.353
Error					

Delay 5					
Source	SS	d.f	MS	F	Sig (p)
SF	24.816	6	4.136	2.299	.035
SF X G	3.864	6	.644	.358	.905
Error	428.238	238	1.799		
Group	8.176	1	8.176	4.544	.034
Error					

Delay 6					
Source	SS	d.f	MS	F	Sig (p)
SF	23.022	6	3.837	3.095	.006
SF X G	10.849	6	1.808	1.459	.194
Error	269.004	217	1.240		
Group	52.087	1	52.087	42.017	.000
Error					

Delay 7					
Source	SS	d.f	MS	F	Sig (p)
SF	32.531	6	5.422	3.595	.002
SF X G	22.285	6	3.714	2.462	.026
Error	285.081	189	1.508		
Group	41.807	1	41.807	27.717	.000
Error					

Appendix E3 – Owners and Contractors – Post Hoc

Delay 1					Delay 2			
(I) SF	(J) SF	Mean (I – J)	Sig (p)		(I) SF	(J)SF	Mean (I-J)	Sig (p)
1	6	.8056	.017		1	3	.5682	.023
5	3	.7506	.026		1	5	-.5682	.023
5	6	.9444	.005		1	6	.8864	.000
					2	5	-.8636	.001
					2	6	.5909	.018
					3	4	-.5455	.029
					3	5	-1.1364	.000
					4	5	-.5909	.018
					4	6	.8636	.001
					5	6	1.4545	.000
					5	7	.8636	.001
					6	7	-.5909	.018
Delay 3					**Delay 4**			
(I) SF	(J) SF	Mean (I – J)	Sig (p)		(I) SF	(J)SF	Mean (I-J)	Sig (p)
1	6	.9714	.001		1	3	.7292	.002
2	6	.6571	.025		1	4	.5417	.018
3	6	.6000	.040		1	5	-.6250	.007
4	6	.7143	.015		2	3	.9167	.000
5	6	1.0857	.000		2	4	.7292	.002
6	7	-.7714	.009		2	5	-.4375	.056
					3	5	-1.3542	.000
					3	6	-.8125	.000
					3	7	-.8333	.000
					4	5	-1.1667	.000
					4	6	-.6250	.007
					4	7	-.6458	.005
					5	6	.5417	.018
					5	7	.5208	.023
Delay 5					**Delay 6**			
(I) SF	(J) SF	Mean (I – J)	Sig (p)		(I) SF	(J)SF	Mean (I-J)	Sig (p)
1	6	.6389	.044		1	3	.6970	.012
2	5	-.6667	.036		1	6	.9394	.001
3	5	-.7778	.015		2	3	.5758	.037
4	6	.6667	.036		2	6	.8182	.003
5	6	1.1389	.000		3	4	-.0606	.021
6	7	-.6944	.029		3	5	-.6970	.012
					4	6	.8788	.002
					5	6	.9394	.001
					6	7	-.5455	.048
Delay 7								
(I) SF	(J) SF	Mean (I – J)	Sig (p)					
1	3	.7586	.020					
1	6	1.2414	.000					
2	6	-.8276	.011					
3	5	-.7931	.015					
4	6	.9310	.004					
5	6	1.2759	.000					
6	7	-.8276	.011					

Appendix E4 – Contractor and Engineer

Delay 1						
	Contractor n = 17		Engineer n= 30		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.5882	1.50245	4.0667	.82768	3.8275	4
2	3.0588	1.34493	3.7000	.87691	3.3794	1
3	2.5882	1.32565	3.3667	.92786	2.9775	7
4	3.4118	1.46026	4.3667	.99943	3.8893	2
5	3.8235	1.46779	4.7000	.59596	2.8586	3
6	2.6471	1.53872	3.1667	1.17688	2.9069	6
7	3.3529	1.32009	3.7000	.87691	3.5265	5
M	3.2101		3.8667			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Delay 2						
	Contractor n = 27		Engineer n= 38		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.9259	1.41220	4.1579	.91611	4.0419	5
2	3.4815	1.18874	3.9211	1.30242	3.7013	1
3	3.2222	.93370	3.2105	1.59658	3.2163	4
4	3.8519	1.37851	4.1579	.91611	4.0049	2
5	4.4074	.88835	4.1579	.91611	4,2827	7
6	2.7778	.80064	3.1316	1.43642	2.9569	3
7	3.6296	1.07946	3.6842	1.42622	3.6569	6
M	3.6138		3.7744			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Delay 3						
	Contractor n = 20		Engineer n= 32		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	4.2000	1.00525	4.5625	.61892	4.3813	1
2	4.0000	1.29777	4.0938	.22762	4.0469	5
3	3.7500	1.16416	3.1563	1.32249	3.4532	7
4	3.7500	1.16416	4.0625	1.10534	3.9063	2
5	4.3500	.98809	4.3750	.79312	4.3625	4
6	3.0000	1.02598	3.5313	1.07716	3.2657	3
7	4.0000	1.21395	4.4688	.76134	4.2344	6
M	3.8643		4.0357			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Delay 4						
	Contractor n = 16		Engineer n= 32		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	4.1250	.95743	3.4063	1.34066	3.7657	5
2	3.0625	1.38894	4.2188	.87009	3.6407	1
3	3.1250	1.31022	2.8125	1.22967	2.9688	7
4	3.6875	1.01448	2.8125	1.22967	3.2500	2
5	4.2500	1.12546	4.2813	.99139	4.2657	6
6	2.6250	.95743	4.2813	1.05446	3.4532	4
7	3.8125	.91059	3.7188	1.08462	3.7657	3
M	3.5268		3.6473			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Delay 5						
	Contractor n = 20		Engineer n= 36		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.6000	1.39170	3.2222	1.56955	3.4111	5
2	3.4000	1.14248	3.0833	1.50000	3.2417	7
3	3.2500	1.25132	2.9444	1.30809	3.0972	4
4	3.4500	1.19097	3.6944	1.47007	3.5722	1
5	4.1000	1.25237	4.3333	.95618	4.2167	2
6	2.7500	1.25132	2.8611	1.41730	2.8056	3
7	3.8000	1.39925	3.6667	1.41421	3.7334	6
M	3.4786		3.4008			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Delay 6						
	Contractor n =		Engineer n= 36		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	4.4211	1.01739	4.1667	1.10841	4.2939	1
2	4.1579	.89834	3.8056	1.19090	3.9818	5
3	3.2632	.87191	2.7778	1.33333	3.0206	2
4	4.1579	.89834	3.5556	1.25230	3.6568	7
5	4.3684	.76089	4.0278	1.15847	4.1981	4
6	3.0000	1.05409	2.7778	1.35459	2.8889	3
7	4.0000	.88192	3.6944	1.26083	3.8472	6
M	3.9098		3.5437			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Delay 7						
	Contractor n = 15		Engineer n= 36		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	4.6667	.61721	4.3611	.86694	4.5139	5
2	3.8000	1.37321	3.6944	1.06421	3.7472	1
3	3.2667	1.38701	4.0278	1.08196	3.6473	7
4	3.8667	1.35576	4.1389	1.09942	4.0028	4
5	4.6667	.89974	4.3056	.92023	4.4862	2
6	2.5333	.99043	3.5000	1.10841	3.0167	3
7	4.2000	.94112	4.3611	.89929	4.2806	6
M	3.8571		4.0556			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Appendix E5 – Contractors and Engineers – Main effects – Calculation

Delay 1					
Source	SS	d.f	MS	F	Sig (p)
SF	63.752	6	10.625	8.444	.000
SF X G	3.242	1	.540	.429	.859
Error	396.396	315	1.258		
Group	32.745	1	32.745	26.021	.000
Error					
SF: success factors, SFXG: Success factors by group(interaction, SS: Sum of squares, df: degree of freedom, MS: Mean square					

Delay 2					
Source	SS	d.f	MS	F	Sig (p)
SF	84.627	6	14.105	9.890	.000
SF X G	5.533	6	.922	.647	.693
Error	628.938	441	1.426		
Group	2.853	1	2.853	2.000	.158
Error					

Delay 3					
Source	SS	d.f	MS	F	Sig (p)
SF	46.343	6	7.724	6.070	.000
SF X G	.000	6	.000	.000	1.000
Error	338.500	266	1.273		
Group	.000	1	.000	.000	.000
Error					

Delay 4					
Source	SS	d.f	MS	F	Sig (p)
SF	44.414	6	7.402	5.909	.000
SF X G	57.259	6	9.543	7.617	.000
Error	403.406	322	1.253		
Group	1.085	1	1.085	.866	.353
Error					

Delay 5					
Source	SS	d.f	MS	F	Sig (p)
SF	65.156	6	10.859	5.968	.000
SF X G	5.636	6	.939	.516	.796
Error	687.856	378	1.820		
Group	.544	1	.544	.299	.585
Error					

Delay 6					
Source	SS	d.f	MS	F	Sig (p)
SF	91.584	6	15.264	11.740	.000
SF X G	1.340	6	.223	.172	.984
Error	482.373	371	1.300		
Group	11.669	1	11.669	8.975	.003
Error					

Delay 7					
Source	SS	d.f	MS	F	Sig (p)
SF	72.892	6	12.149	11.201	.000
SF X G	16.657	6	2.776	2.559	.019
Error	372.033	343	1.085		
Group	2.918	1	2.918	2.690	.102
Error					

Appendix E6 – Contractors and Engineers – Post Hoc

Delay 1				Delay 2			
(I) SF	(J) SF	Mean (I – J)	Sig (p)	(I) SF	(J)SF	Mean (I-J)	Sig (p)
1	3	.8085	.001	1	3	.8462	.000
1	5	-.4894	.035	1	6	1.0769	.000
1	6	.9149	.000	2	3	.5231	.013
2	4	-.5332	.017	2	5	-.5231	.013
2	5	-.9149	.000	2	6	.7358	.000
2	6	-.4894	.035	3	4	-.8154	.000
3	4	-.9632	.000	3	5	-1.0642	.000
3	5	-1.2979	.000	3	7	-.4462	.034
3	7	-.4894	.035	4	6	1.0462	.000
4	6	1.0426	.000	5	7	.6000	.004
5	6	1.4043	.000	6	7	-.6769	.001
5	7	.8085	.001				
6	7	-.5957	.010				

Delay 3				Delay 4			
(I) SF	(J) SF	Mean (I – J)	Sig (p)	(I) SF	(J)SF	Mean (I-J)	Sig (p)
1	6	1.2000	.000	1	3	.7292	.002
2	6	1.0000	.000	1	4	.5417	.018
3	5	-.6000	.018	1	5	-.6250	.007
3	6	.7500	.003	2	3	.9167	.000
4	5	-.6000	.018	2	4	.7292	.002
4	6	.7500	.003	3	5	-1.3542	.000
5	6	.7500	.000	3	6	-.8125	.000
6	7	-1.000	.000	3	7	-.8333	.000
				4	5	-1.667	.000
				4	6	-.6350	.000
				4	7	-.6458	.000
				5	6	.5417	.018
				5	7	.5208	.023
Delay 5				**Delay6**			
(I) SF	(J) SF	Mean (I – J)	Sig (p)	(I) SF	(J)SF	Mean (I-J)	Sig (p)
1	5	-.8929	.001	1	3	1.3091	.000
1	6	.5357	.036	1	4	.4909	.025
2	5	-1.0536	.000	1	6	1.4000	.000
2	7	-.5179	.043	1	7	.4545	.037
3	4	-.5536	.031	2	3	.9818	.000
3	5	-1.1964	.000	2	6	1.0727	.000
3	7	-.5179	.043	3	4	-.8182	.000
4	5	-.6429	.012	3	5	-1.2000	.000
4	6	.7857	.002	3	7	-.8545	.000
5	6	1.4286	.000	4	5	-.3818	.080

5	7	.5357	.036	4	6	.9091	.000
6	7	-.8929	.001	5	6	1.2909	.000
				6	7	-.9545	.000
Delay 7							
(I) SF	(J) SF	Mean (I – J)	Sig (p)				
1	2	.7255	.000				
1	3	.6471	.002				
1	6	1.2353	.000				
2	5	-.6863	.001				
2	6	.5098	.014				
2	7	-.5882	.005				
3	5	-.6078	.003				
3	6	.5882	.005				
3	7	-.5098	.014				
4	6.	.8431	.000				
5	6	1.1961	.000				
6	7	-1.0980	.000				

Appendix E7 – Owner and Engineer

Delay 1						
	Owner n = 19		Engineer n = 30		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.6316	1.46099	4.0667	.82768	3.8492	5
2	3.3158	1.41628	3.7000	.87691	3.5079	4
3	3.3684	1.42246	3.3667	.92786	3.3676	1
4	3.4737	1.54087	4.3667	.99943	3.9202	7
5	3.6842	1.45498	4.7000	.59596	4,1921	2
6	2.9474	1.31122	3.1667	1.17688	3.0571	3
7	3.3684	1.34208	3.7000	.87691	3.5342	6
M	3.3985		3.8667			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF’s effect) or column (group effect)						

Delay 2						
	Owner n = 17		Engineer n = 38		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	
1	3.2353	1.34766	4.1579	.91611	3.6966	5
2	3.1765	1.23669	3.9211	1.30242	3.5488	4
3	2.8824	1.26897	3.2105	1.59658	3.0465	1
4	3.2941	1.15999	4.1579	.91611	3.7260	2
5	3.9412	1.24853	4.1579	.91611	3.7260	7
6	2.7647	1.09141	3.1316	1.43642	2.9482	3
7	2.9412	1.29762	3.6842	1.42622	3.3127	6
M	3.1765		3.7744			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Delay 3						
	Owner n =15		Engineer n= 32		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	
1	3.4000	1.35225	4.5625	.61892	3.9813	1
2	2.9333	1.27988	4.0938	1.22762	3.5136	5
3	3.1333	1.30201	3.1563	1.32249	3.1448	7
4	3.4000	1.35225	4.0625	1.10534	3.7313	4
5	3.4667	1.45733	4.3750	.79312	3.9209	2
6	2.7333	1.22280	3.5313	1.07716	3.1323	3
7	3.2000	1.32017	4.4688	.76134	3.8344	6
M	3.1810		4.0357			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Delay 4						
	Owner n = 18		Engineer n= 32		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	
1	3.6111	1.46082	3.4063	1.34066	3.5087	2
2	3.2222	1.47750	4.2188	.87009	3.7205	7
3	3.2778	1.44733	2.8125	1.22967	3.0452	5
4	3.5000	1.46528	2.8125	1.22967	3.1563	6
5	3.0000	1.49509	4.2813	.99139	3.6407	1
6	3.0000	1.49509	4.2813	1.05446	3.6407	4
7	3.7222	1.27443	3.7188	1.08462	3.7205	3
M	3.3333		3.6473			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Delay 5						
	Owner n = 16		Engineer n= 36		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.1250	1.50000	3.2222	1.56955	3.1736	5
2	3.0000	1.41421	3.0833	1.50000	3.0417	4
3	2.9375	1.52616	2.9444	1.30809	2.9410	7
4	3.3750	1.36015	3.6944	1.47007	3.5347	1
5	3.6250	1.36015	4.3333	.95618	3.9790	2
6	2.7500	1.39044	2.8611	1.41730	2.8056	3
7	3.0000	1.41421	3.6667	1.41421	3.3334	6
M	3.1161		3.4008			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Delay 6						
	Owner n = 14		Engineer n= 36		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.0000	1.35873	4.1667	1.10841	3.5834	1
2	3.0714	1.32806	3.8056	1.19090	3.4385	5
3	2.9286	1.26881	2.7778	1.33333	2.8532	2
4	3.2143	1.42389	3.5556	1.25230	3.3850	4
5	3.0714	1.32806	4.0278	1.15847	3.5496	7
6	2.7143	1.38278	2.7778	1.35459	2.7461	3
7	2.6429	1.27745	3.6944	1.26083	3.1687	6
M	2.9490		3.5437			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Delay 7						
	Owner n = 17		Engineer n= 36		Marginal mean owner + contractor)/2	Sorting Highest to Lowest
Success Factor	Mean	St.D	Mean	St.D	M	SF
1	3.5882	1.27764	4.3611	.86694	3.9747	5
2	2.9412	1.51948	3.6944	1.06421	3.3178	1
3	3.5294	1.32842	4.0278	1.08196	3.7786	7
4	3.5294	1.46277	4.1389	1.09942	3.8342	4
5	3.7647	1.25147	4.3056	.92023	4.0352	3
6	2.7059	1.35852	3.5000	1.10841	3.1030	2
7	3.4118	1.32565	4.3611	.89929	3.8865	6
M	3.3529		4.0556			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)						

Appendix E8 – Owners and Engineers – Main effects – Calculation

Delay 1					
Source	SS	d.f	MS	F	Sig (p)
SF	40.454	6	6.742	5.231	.000
SF X G	9.189	6	1.531	1.188	.312
Error	424.025	329	1.289		
Group	17.848	1	17.848	13.848	.000
Error					
SF: success factors, SFXG: Success factors by group(interaction, SS: Sum of squares, df: degree of freedom, MS: Mean square					

Delay 2					
Source	SS	d.f	MS	F	Sig (p)
SF	43.939	6	7.323	4.745	.000
SF X G	5.757	6	.959	.622	.713
Error	572.554	371	1.543		
Group	29.398	1	29.398	19.049	.000
Error					

Delay 3					
Source	SS	d.f	MS	F	Sig (p)
SF	23.122	6	3.854	2.602	.019
SF X G	4.314	6	.719	.485	.819
Error	342.183	231	1.481		
Group	28.017	1	28.017	18.913	.000
Error					

Delay 4					
Source	SS	d.f	MS	F	Sig (p)
SF	21.255	6	3.542	2,274	.036
SF X G	49.735	6	8.289	5.321	.000
Error	523.455	336	1.558		
Group	7.950	1	7.950	5.103	.025
Error					

Delay 5					
Source	SS	d.f	MS	F	Sig (p)
SF	42.600	6	7.100	3.623	.002
SF X G	5.644	6	.941	.480	.823
Error	685.993	350	1.960		
Group	6.286	1	6.286	3.207	.074
Error					

Delay 6					
Source	SS	d.f	MS	F	Sig (p)
SF	27.119	6	4.520	2.813	.011
SF X G	16.010	6	2.668	1.661	.130
Error	539.798	336	1.607		
Group	24.952	1	24.952	15.532	.000
Error					

Delay7					
Source	SS	d.f	MS	F	Sig (p)
SF	34.601	6	5.767	4.491	.000
SF X G	1.770	6	.295	.230	.967
Error	458.402	357	1.284		
Group	39.903	1	39.903	31.076	.000
Error					

Appendix E9 – Owner and Engineers – Post Hoc

Delay 1					Delay 2			
(I) SF	(J) SF	Mean (I – J)	Sig (p)		(I) SF	(J)SF	Mean (I-J)	Sig (p)
1	3	.6515	.002		1	3	.7636	.001
1	6	.8485	.000		1	6	.8545	.000
2	4	-.4394	.038		2	3	.5818	.015
2	5	-.7576	.000		2	6	.6727	.005
2	6	.4545	.032		3	4	-.7818	.001
3	4	-.4394	.001		3	5	-9818	.000
3	5	-1.1052	.000		4	6	.8727	.000
4	6	.8939	.000		5	6	1.0727	.000
5	6	1.2121	.000		5	7	.6364	.008
5	7	.6667	.002					
6	7	-.5455	.10					

Delay 3					Delay 4			
(I) SF	(J) SF	Mean (I – J)	Sig (p)		(I) SF	(J)SF	Mean (I-J)	Sig (p)
1	6	.9714	.001		1	3	.5000	.046
2	6	.6571	.025		2	3	.8800	.000
3	6	.6000	.040		2	4	.8000	.001
4	6	.7143	.015		3	5	-.8400	.001
5	6	1.0857	.000		3	6	-.8400	.001
6	7	-.7714	.009		3	7	-.7400	.003
					4	5	-.7600	.003
					4	6	-.7600	.003
					4	7	-.6600	.009

Delay 5					Delay 6			
(I) SF	(J) SF	Mean (I – J)	Sig (p)		(I) SF	(J)SF	Mean (I-J)	Sig (p)
1	5	-.9231	.001		1	3	1.0200	.000
2	5	-1.0577	.000		1	6	1.0800	.000
3	4	-.6538	.018		2	3	.7800	.002
3	5	-1.1731	.000		2	6	.8400	.001
4	6	.7692	.005		3	4	-.6400	.012
5	6	1.2885	.000		3	5	-.9400	.000
6	7	-.6346	.021		3	7	-.5800	.023
					4	6	.7000	.006
					5	6	1.0000	.000
					6	7	-.6400	.012

Delay 7			
(I) SF	(J) SF	Mean (I – J)	Sig (p)
1	2	.6604	.003
1	6	.8679	.000
2	4	-.4906	.026
2	5	-.6792	.002
2	7	-.6038	.006
3	6	.6226	.005
4	6	.6981	.002
5	6	.8868	.000
6	7	-.8113	.000

Appendix E10 – Owner, Contractor and Engineer

Delay 1								
	Owner n = 19		Contractor n= 17		Engineer n = 30		Marginal mean owner + contractor)/3	Sorting Highest to Lowest
SF	Mean	St.D	Mean	St.D	Mean	St.D	M	SF
1	3.6316	1.46099	3.5882	1.50245	4.0667	.82768	3.7622	5
2	3.3158	1.41628	3.0588	1.34493	3.7000	.87691	3.3582	1
3	3.3684	1.42246	2.5882	1.32565	3.3667	.92786	3.1078	4
4	3.4737	1.54087	3.4118	1.46026	4.3667	.99943	3.7507	7
5	3.6842	1.45498	3.8235	1.46779	4.7000	.59596	4.0692	2
6	2.9474	1.31122	2.6471	1.53872	3.1667	1.17688	2.9204	3
7	3.3684	1.34208	3.3529	1.32009	3.7000	.87691	3.4738	6
M	3.3985		3.2101		3.8667			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)								

Delay 2								
	Owner n = 19		Contractor n= 17		Engineer n = 30		Marginal mean owner + contractor)/3	Sorting Highest to Lowest
SF	Mean	St.D	Mean	St.D	Mean	St.D	M	SF
1	3.2353	1.34766	3.9259	1.41220	4.1579	.91611	3.7730	5
2	3.1765	1.23669	3.4815	1.18874	3.9211	1.30242	3.5264	4
3	2.8824	1.26897	3.2222	.93370	3.2105	1.59658	3.1050	1
4	3.2941	1.15999	3.8519	1.37851	4.1579	.91611	3.9531	2
5	3.9412	1.24853	4.4074	.88835	4.1579	.91611	4.1688	7
6	2.7647	1.09141	2.7778	.80064	3.1316	1.43642	2.8914	3
7	2.9412	1.29762	3.6296	1.07946	3.6842	1.42622	3.4183	6
M	3.1765		3.6138		3.7744			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)								

Delay 3								
	Owner n = 19		Contractor n= 17		Engineer n = 30		Marginal mean owner + contractor)/3	Sorting Highest to Lowest
SF	Mean	St.D	Mean	St.D	Mean	St.D	M	SF
1	3.4000	1.35225	4.2000	1.00525	4.5625	.61892	4.0542	5
2	2.9333	1.27988	4.0000	1.29777	4.0938	1.22762	3.6757	1
3	3.1333	1.30201	3.7500	1.16416	3.1563	1.32249	3.3465	7
4	3.4000	1.35225	3.7500	1.16416	4.0625	1.10534	3.7375	4
5	3.4667	1.45733	4.3500	.98809	4.3750	.79312	4.0639	2
6	2.7333	1.22280	3.0000	1.02598	3.5313	1.07716	3.0882	3
7	3.2000	1.32017	4.0000	1.21395	4.4688	.76134	3.8896	6
M	3.1810		3.8643		4.0357			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)								

Delay 4								
	Owner n = 19		Contractor n= 17		Engineer n = 30		Marginal mean owner + contractor)/3	Sorting Highest to Lowest
SF	Mean	St.D	Mean	St.D	Mean	St.D	M	SF
1	3.6111	1.46082	4.1250	.95743	3.4063	1.34066	3.7141	5
2	3.2222	1.47750	3.0625	1.38894	4.2188	.87009	3.5011	7
3	3.2778	1.44733	3.1250	1.31022	2.8125	1.22967	3.0718	1
4	3.5000	1.46528	3.6875	1.01448	2.8125	1.22967	3.3333	2
5	3.0000	1.49509	4.2500	1.12546	4.2813	.99139	3.8438	4
6	3.0000	1.49509	2.6250	.95743	4.2813	1.05446	3.3021	6
7	3.7222	1.27443	3.8125	.91059	3.7188	1.08462	3.7512	3
M	3.3333		3.5268		3.6473			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)								

Delay 5								
	Owner n = 19		Contractor n= 17		Engineer n = 30		Marginal mean owner + contractor)/3	Sorting Highest to Lowest
SF	Mean	St.D	Mean	St.D	Mean	St.D	M	SF
1	3.1250	1.50000	3.6000	1.39170	3.2222	1.56955	3.3157	5
2	3.0000	1.41421	3.4000	1.14248	3.0833	1.50000	3.1611	4
3	2.9375	1.52616	3.2500	1.25132	2.9444	1.30809	3.0440	7
4	3.3750	1.36015	3.4500	1.19097	3.6944	1.47007	3.5064	1
5	3.6250	1.36015	4.1000	1.25237	4.3333	.95618	4.0194	2
6	2.7500	1.39044	2.7500	1.25132	2.8611	1.41730	2.7870	3
7	3.0000	1.41421	3.8000	1.39925	3.6667	1.41421	3.4889	6
M	3.1161		3.4786		3.4008			

SF : Success Factors,
ST,D : Standard Deviation
Marginal or (M0 : accumulative mean by raw
(SF's effect) or column (group effect)

Delay 6								
	Owner n = 14		Contractor n=		Engineer n =36		Marginal mean owner + contractor)/3	Sorting Highest to Lowest
SF	Mean	St.D	Mean	St.D	Mean	St.D	M	SF
1	3.0000	1.35873	4.4211	1.01739	4.1667	1.10841	3.8626	1
2	3.0714	1.32806	4.1579	.89834	3.8056	1.19090	3.6783	5
3	2.9286	1.26881	3.2632	.87191	2.7778	1.33333	2.9899	2
4	3.2143	1.42389	4.1579	.89834	3.5556	1.25230	3.6426	4
5	3.0714	1.32806	4.3684	.76089	4.0278	1.15847	3.8225	7
6	2.7143	1.38278	3.0000	1.05409	2.7778	1.35459	2.8307	3
7	2.6429	1.27745	4.0000	.88192	3.6944	1.26083	3.4458	6
M	2.9490		3.9098		3.5437			

SF : Success Factors,
ST,D : Standard Deviation
Marginal or (M0 : accumulative mean by raw
(SF's effect) or column (group effect)

Delay 7								
	Owner n = 17		Contractor n= 15		Engineer n = 36		Marginal mean owner + contractor)/3	Sorting Highest to Lowest
SF	Mean	St.D	Mean	St.D	Mean	St.D	M	SF
1	3.5882	1.27764	4.6667	.61721	4.3611	.86694	4.2053	5
2	2.9412	1.51948	3.8000	1.37321	3.6944	1.06421	3.4785	1
3	3.5294	1.32842	3.2667	1.38701	4.0278	1.08196	3.6080	7
4	3.5294	1.46277	3.8667	1.35576	4.1389	1.09942	3.7784	4
5	3.7647	1.25147	4.6667	.89974	4.3056	.92023	4.2457	3
6	2.7059	1.35852	2.5333	.99043	3.5000	1.10841	2.9131	2
7	3.4118	1.32565	4.2000	.94112	4.3611	.89929	3.9910	6
M	3.3529		3.8571		4.0556			
SF : Success Factors, ST,D : Standard Deviation Marginal or (M0 : accumulative mean by raw (SF's effect) or column (group effect)								

Appendix E11 – Owners, Contractors and Engineers – Main effects – Calculation

Delay 1					
Source	SS	d.f	MS	F	Sig (p)
SF	60.031	6	10.005	6.772	.000
SF X G	11.782	12	.982	.665	.786
Error	651.554	441	1.477		
Group	37.785	2	18.893	12.787	.000
Error					
SF: success factors, SFXG: Success factors by group(interaction, SS: Sum of squares, df: degree of freedom, MS: Mean square					

Delay 2					
Source	SS	d.f	MS	F	Sig (p)
SF	82.816	6	13.803	9.533	.000
SF X G	10.204	12	.850	.587	.853
Error	800.702	553	1.448		
Group	29.472	2	14.736	10.177	.000
Error					

Delay 3					
Source	SS	d.f	MS	F	Sig (p)
SF	43.623	6	7.270	5.175	.000
SF X G	5.491	12	.458	.326	.984
Error	511.433	364	1.405		
Group	35.658	2	17.829	12.689	.000
Error					

Delay 4					
Source	SS	d.f	MS	F	Sig (p)
SF	28.777	6	4.796	3.241	.004
SF X G	87.164	12	7.264	4.909	.000
Error	652.517	441	1.480		
Group	7.955	2	3.977	2.688	.069
Error					

Delay 5					
Source	SS	d.f	MS	F	Sig (p)
SF	60.119	6	10.020	5.371	.000
SF X G	10.392	12	.866	.464	.935
Error	901.043	483	1.866		
Group	9.051	2	4.526	2.426	.089
Error					

Delay 6					
Source	SS	d.f	MS	F	Sig (p)
SF	58.763	6	9.794	7.009	.000
SF X G	17.858	12	1.488	1.065	.388
Error	645.587	462	1.397		
Group	52.294	2	26.147	18.712	.000
Error					

Delay 7					
Source	SS	d.f	MS	F	Sig (p)
SF	48.959	6	8.160	6.673	.000
SF X G	29.172	12	2.431	1.988	.024
Error	529.513	433	1.223		
Group	88.709	2	44.355	36.270	.000
Error					

Appendix E12 – Owners, Contractors and Engineers – Post Hoc

Delay 1					Delay 2			
(I) SF	(J) SF	Mean (I – J)	Sig (p)		(I) SF	(J)SF	Mean (I-J)	Sig (p)
1	3	.6515	.002		1	3	.7439	.000
1	6	.8485	.000		1	6	.9512	.000
2	4	-.4394	.038		1	7	.3780	.045
2	5	-.7576	.000		2	3	.4756	.012
2	6	.4545	.032		2	5	-.5732	.002
3	4	-.6970	.001		2	6	.6829	.000
3	5	-1.0572	.000		3	4	-.7317	.000
4	6	.8939	.000		3	5	-1.0488	.000
5	6	1.2121	.000		4	6	.9390	.000
5	7	.6667	.002		5	6	1.2561	.000
6	7	-.5455	.010		5	7	.6829	.000
					6	7	-.5732	.002

Delay 3					Delay 4			
(I) SF	(J) SF	Mean (I – J)	Sig (p)		(I) SF	(J)SF	Mean (I-J)	Sig (p)
1	6	1.0545	.000		1	3	.6212	.004
2	6	.7818	.001		1	4	.4242	.046
3	5	-.5237	.020		2	3	.6515	.002
3	6	.6545	.004		2	4	.4545	.032
4	5	-.4545	.045		3	5	-.9091	.000
4	6	.7273	.001		3	6	-.5152	.015
5	6	1.1818	.000		3	7	-.7273	.001
6	7	-.8545	.000		4	5	-.7121	.001
					4	7	-.5303	.013

Delay 5					Delay 6			
(I) SF	(J) SF	Mean (I – J)	Sig (p)		(I) SF	(J)SF	Mean (I-J)	Sig (p)
1	5	-.8056	.000		1	3	1.0580	.000
1	6	.5000	.029		1	6	1.1739	.000
2	5	-.9583	.000		1	7	.4348	.031
3	4	-.5278	.021		2	3	.8116	.000
3	5	-1.0833	.000		2	6	.9275	.000
3	7	-.5278	.021		3	4	-.7101	.000
4	5	-.5556	.015		3	5	-.9855	.000
4	6	.7500	.001		3	7	-.6232	.002
5	6	1.3056	.000		4	6	.8261	.000
5	7	.5556	.015		5	6	1.1014	.000
6	7	-.7500	.001		6	7	-.7391	.000

Delay 7			
(I) SF	(J) SF	Mean (I – J)	Sig (p)
1	2	.5873	.003
1	3	.5565	.004
1	6	1.0642	.000
2	5	-.5385	.006
2	6	.4769	.014
3	5	-.5077	.009.
3	6	-.3385	.009
4	6	.7692	.000
5	6	1.0154	.000
6	7	-.8462	.000

APPENDIX F – Relative Importance of the Success Factors

Individual Overall Importance

Appendix F1 – One-Way ANOVA Results for Owners

	D1	D2	D3	D4	D5	D6	D7	SF	SF Importance	Sorting
S	5	5	5	7	5	4	5	S1	38	S5
S	1	4	1	1	4	5	1	S2	22	S4
S	4	1	4	4	1	2	4	S3	21	S1
S	7	2	7	3	2	1	3	S4	39	S2
S	3	7	3	2	7	3	7	S5	43	S7
S	2	3	2	5	3	6	2	S6	8	S3
S	6	6	6	6	6	7	6	S7	22	S6

S1 : Organisational planning S2 : Project manager's goal commitment S3 : Project team's motivation and goal orientation S4 : Clarity of the project scope and work definition S5 : Project manager's capabilities and experience S6 : Safety precautions and applied procedures S7 : Use of control system	D1 : Lack of communication between parties D2: Slow decision making D3 : Change orders D4 : Inadequate contractor planning D5 : Finance and payment of completed work D6 : Subcontractors D7 : Inadequate contractor experience

Appendix F2 – One-Way ANOVA Results for Contractor

	D1	D2	D3	D4	D5	D6	D7	SF	SF Importance	Sorting
S	5	5	5	5	5	1	1	S1	43	S5
S	1	1	1	1	7	5	5	S2	24	S1
S	4	4	2	7	1	2	7	S3	14	S7
S	7	7	7	4	4	4	4	S4	29	S4
S	2	2	3	3	2	7	2	S5	47	S2
S	6	3	4	2	3	3	3	S6	8	S3
S	3	6	6	6	6	6	6	S7	31	S6

Appendix F3 – One-Way ANOVA Results for Engineer

	D1	D2	D3	D4	D5	D6	D7	SF	SF Importance	Sorting
S	5	1	1	5	5	1	1	S1	40	S5
S	4	4	7	6	4	5	7	S2	27	S1
S	1	5	5	2	7	2	5	S3	14	S7
S	2	2	2	7	1	7	4	S4	29	S4
S	7	7	4	1	2	4	3	S5	40	S2
S	3	3	6	3	3	3	2	S6	13	S3
S	6	6	3	4	6	6	6	S7	31	S6

Group Overall Importance

Appendix F4 – Two-Way ANOVA Results for Owner and Contractor

	D1	D2	D3	D4	D5	D6	D7	SF	SF Importance	Sorting
S	5	5	5	1	5	5	5	S1	41	S5
S	1	1	1	7	4	1	1	S2	21	S1
S	4	4	7	5	7	4	7	S3	16	S4
S	7	2	4	4	1	2	4	S4	33	S7
S	2	7	2	3	2	7	3	S5	47	S2
S	3	3	3	2	3	3	2	S6	7	S3
S	6	6	6	6	6	6	6	S7	31	S6

Appendix F5 – Two-Way ANOVA Results for Contractor and Engineer

	D1	D2	D3	D4	D5	D6	D7	SF	SF Importance	Sorting
S	5	5	1	5	5	1	5	S1	41	S5
S	4	1	5	1	7	5	1	S2	26	S1
S	1	4	7	7	4	2	7	S3	13	S7
S	7	2	2	2	1	7	4	S4	28	S4
S	2	7	4	6	2	4	2	S5	47	S2
S	3	3	3	4	3	3	3	S6	8	S3
S	6	6	6	3	6	6	6	S7	32	S6

Appendix F6 – Two-Way ANOVA Results for Owner and Engineer

	D1	D2	D3	D4	D5	D6	D7	SF	SF Importance	Sorting
S	5	5	1	2	5	1	5	S1	37	S5
S	4	4	5	7	4	5	1	S2	27	S1
S	1	1	7	5	7	2	7	S3	14	S4
S	7	2	4	6	1	4	4	S4	32	S7
S	2	7	2	1	2	7	3	S5	45	S2
S	3	3	3	4	3	3	2	S6	10	S3
S	6	6	6	3	6	6	6	S7	31	S6

Appendix F7 – Two-Way ANOVA Results for Owner, Contractor and Engineer

	D1	D2	D3	D4	D5	D6	D7	SF	SF Importance	Sorting
S	5	5	5	5	5	1	5	S1	39	S5
S	1	4	1	7	4	5	1	S2	24	S1
S	4	1	7	1	7	2	7	S3	14	S7
S	7	2	4	2	1	4	4	S4	32	S4
S	2	7	2	4	2	7	3	S5	48	S2
S	3	3	3	6	3	3	2	S6	8	S3
S	6	6	6	3	6	6	6	S7	7	S6

APPENDIX G

Application to conduct research in Brunei Government Construction Industry. (sample letter)

Date

Minister of Development Office
Old Airport
Brunei Darussalam

Dear Sir,

RE: Application to conduct research in several Brunei government departments

My name is Rohaniyati Salleh. I am currently undertaking PhD in project management in Queensland University of Technology. In accordance with the protocol of Ministry of Development pertaining to conduct research in the government departments, I wish to seek permission and approval to conduct research with the government authority.

My area of interest is construction industry. The focus of this research centres on failure factors of Building construction for public sectors under Ministry of Development and to suggest some strategies to improve project performance.

Your cooperation and kind consideration in this matter is highly appreciated. Please do not hesitate to contact me if any issues in the application require clarification
Yours Sincerely

LETTER TO STAKEHOLDERS FOR THE SURVEY ON THE LOCAL CONSTRUCTION INDUSTRY OF BRUNEI

Dear participant,

The construction industry is one of a major contributor to the national economy of many countries. The construction industry in Brunei is characterized by severe problems and the researcher aim is to improve efficiency, quality, and performance of the industry,
The survey's main question is:

What are the real causes of project failures in Brunei construction industry?

As a key stakeholder, you are invited to participate in a survey of the Brunei Construction Industry. Your input will be important to provide us with an understanding of the industry and key strategies to improve project success in the future. This survey is carefully designed to take the shortest time possible.

I value your participation and thank you for the commitment of time, energy and effort, if you have any further questions, I can be reached at the address below.

Sincerely

Rohaniyati Salleh
PhD candidate
Faculty of Engineering
Queensland University of Technology
Brisbane Queensland 4001
Australia
Emails: r.salleh@student.qut.edu.au
INSTRUCTIONS – Please Review these instructions to be able to answer the questions.

INSTRUCTIONS 1 – please, give your details by ticking one of the boxes provided.

PARTICIPANTS DETAIL		Frequency
Age	< 20	□
	20 - 29	□
	30 - 39	□
	40 - 50	□
	> 50	□
Sex	Male	□
	Female	□
Education	Lower secondary	□
	Upper secondary	□
	Pre-university	□
	University	□
	Post Graduate	□
Types of Organisation	Owners (Govt / Developer)	□
	Consultant/Engineers	□
	Contractors	□
Occupational Level	Non-executive	□
	Executive	□
	Managerial	□
Number of working experience	< 2 Years	□
	2 - 5 Years	□
	6 - 10 years	□
	> 10 years	□
Field of specializations	Building	□
	Infrastructure	□
	Mechanical and electrical	□

	Others	□
Largest project involve based on contract sum	< $10 million	□
	$10 million - $ 50 million	□
	> $ 50 million	□

INSTRUCTION 2 – Please rank the delay factors below in what you consider to be the most important factor of delays. The five point scale ranged from 1(not important), 2 (A small amount), 3 (A moderate amount), 4 (A good deal) and 5 (extremely important

Causes of delays		**1**	**2**	**3**	**4**	**5**
Client related causes	Finance and payments of completed work	□	□	□	□	□
	Owner Interference	□	□	□	□	□
	Slow decision making	□	□	□	□	□
	Unrealistic contract duration and requirements imposed	□	□	□	□	□
Contractor related causes	Subcontractors	□	□	□	□	□
	Site management	□	□	□	□	□
	Construction methods	□	□	□	□	□
	Inadequate planning	□	□	□	□	□
	Mistakes during construction stage	□	□	□	□	□
	Inadequate experience of contractors	□	□	□	□	□
Consultant related causes	Contract management	□	□	□	□	□
	Preparation and approval of drawings	□	□	□	□	□
	Quality assurance / control	□	□	□	□	□
	Waiting time for approval of test and inspection	□	□	□	□	□
Material related causes	Quality of material	□	□	□	□	□
	Shortage of material	□	□	□	□	□

Labour and equipment category causes	Labour supply	◻	◻	◻	◻	◻
	Labour productivity	◻	◻	◻	◻	◻
	Equipment availability and failure	◻	◻	◻	◻	◻
Contract related causes	Change orders	◻	◻	◻	◻	◻
	Mistakes and discrepancies in contract document	◻	◻	◻	◻	◻
Contract relationships related causes	Major disputes and negotiations	◻	◻	◻	◻	◻
	Inappropriate overall organizational structure linking to project	◻	◻	◻	◻	◻
	Lack of communication between the parties	◻	◻	◻	◻	◻
External causes	Climate conditions	◻	◻	◻	◻	◻
	Regulatory changes	◻	◻	◻	◻	◻
	Problem with neighbours	◻	◻	◻	◻	◻
	Unforeseen site conditions	◻	◻	◻	◻	◻

APPENDIX H

CRTICAL DELAY FACTORS AND CRITICAL SUCCESS FACTORS IN BRUNEI BUILDING CONSTRUCTION – GENERAL SURVEY

To the respondents:

This survey is part of academic research that aims to understand the relationship between the success and delay factors in construction projects. As a part of this research, the principal success and delay factors in Building construction projects in Brunei and other countries all over the world studied. With this survey, we would like to investigate the relationships between these factors in order to improve the Building construction delivery process. In the long term, this research could help the contract parties complete project on time, within budget and with the highest quality. All the information you provide will kept in strict confidentiality and it will be only used for academic research. Please answer each question carefully. There is no right or wrong answer. If you are unsure of an answer, please respond with your best estimate. I value your participation and thank you for the commitment of time, energy and effort. If you have any further questions, I can be reach at the address below.

Sincerely,

Rohaniyati Salleh
PhD candidate
Faculty of Building and Environment
Queensland University of Technology,
Brisbane, Queensland, 4001,
Australia
Emails:r-salleh@student.qut.edu.au

Part 1. Information and general experience

Name:

E.Mail:

Which sector do you present?

Owner ☐

Contractor ☐

Engineer ☐

Others ☐

Number of years in construction fields?__________________

Please rank each of the following project types in terms of your level of experience. (1 = most experience)

______ Offices building

______ Residential

______ Hospital

______ School

______ Other, please specify____

Have you ever worked as a site engineer?

☐ Yes, please specify approximate number of projects_____________

☐ No

Have you ever worked as a Project Manager?

☐ Yes, please specify approximate number of projects______________

☐ No

Part 2. Project Factors Evaluation

Based on your overall experience in construction projects in Brunei, in general please evaluate the quality of the following project success or delay factors. Please add and evaluate any additional factors that you have experienced to the list in the space provided.(5 = V good, 4 = Good, 3 = Fair, 2 = Poor and 1 = V.poor)

Success Factors	**5**	**4**	**3**	**2**	**1**
Organization planning					
Project manager's goal commitment					
Project manager's motivation and goal orientation					
Clarity of the project scope and definition					
Project manager capability and experience					
Safety precautions and applied procedure					
Use of control system					
Other______________________					
Other________________________					
Other________________________					
Other________________________					

Delay Factors	**5**	**4**	**3**	**2**	**1**
Lack of communication between parties					
Slow decision making					
Change Orders					
Inadequate contractor's planning					
Owner's finance and payment of completed work					
Subcontractors					

Inadequate contractor experience					
Other_______________________					
Other_________________________					
Other_________________________					
Other_________________________					

Part 3. Relationship between Success and Delay Factors

Below are a series of questions. Each set of items follows a similar format. In each set, you will be asked to indicate the extent to which one feature (delay factor) of the project could have been affected by several other project factors. There is a glossary provided at the end of this document to clarify terms.

1. From your experience in the construction field, to what extend could ***lack of communication between parties*** during construction have been avoided and/or prevented by the factors listed below…..(If there are other factors that could have prevented cash problems, please list and evaluate in the spaces provided below). (5 = Completely, 4 = A good deal, 3 = A moderate amount, 2 = A small amount and 1 = Not at all)

Success Factors	**5**	**4**	**3**	**2**	**1**
Organization planning					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of the project scope and definition					
Project manager's capability and experience					
Safety precautions and applied procedures					
The control system for this project					
Other______________________					
Other________________________					
Other________________________					
Other________________________					

2. From your experience in the construction field, to what extend could ***slow decision making*** during construction have been avoided and/or prevented by the factors listed below…..(If there are other factors that could have prevented cash problems, please list and evaluate in the spaces provided below). (5 = Completely, 4 = A good deal, 3 = A moderate amount, 2 = A small amount and 1 = Not at all)

Success Factors	**5**	**4**	**3**	**2**	**1**
Organization planning					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and definition					
Project manager's capability and experience					
Safety precautions and applied procedures					
Use of control system					
Other______________________					
Other________________________					
Other________________________					
Other________________________					

3. From your experience in the construction field, to what extend could ***a change orders*** during construction have been avoided and/or prevented by the factors listed below…..(If there are other factors that could have prevented cash problems, please list and evaluate in the spaces provided below). (5 = Completely, 4 = A good deal, 3 = A moderate amount, 2 = A small amount and 1 = Not at all)

Success Factors	5	4	3	2	1
Organization planning					
Project manager’s goal commitment					
Project team’s motivation and goal orientation					
Clarity of project scope and definition					
Project manage’sr capability and experience					
Safety record					
Use of control system					
Other______________________					
Other________________________					
Other________________________					
Other________________________					

4. From your experience in the construction field, to what extend ***contractor’s inadequate planning*** construction have been avoided and/or prevented by the factors listed below…..(If there are other factors that could have prevented cash problems, please list and evaluate in the spaces provided below). (5 = Completely, 4 = A good deal, 3 = A moderate amount, 2 = A small amount and 1 = Not at all)

Success Factors	**5**	**4**	**3**	**2**	**1**
Organization planning					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and definition					
Project manager's capability and experience					
Safety precautions and applied procedures					
Use control system					
Other______________________					
Other________________________					
Other________________________					
Other________________________					

5. From your experience in the construction field, to what extend could ***an owner's finance and payment for completed work*** during construction have been avoided and/or prevented by the factors listed below…..(If there are other factors that could have prevented cash problems, please list and evaluate in the spaces provided below). (5 = Completely, 4 = A good deal, 3 = A moderate amount, 2 = A small amount and 1 = Not at all)

Success Factors	**5**	**4**	**3**	**2**	**1**
Organization planning					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and definition					
Project manager's capability and experience					
Safety precautions and applied procedures					
Use of control system					
Other______________________					
Other________________________					
Other________________________					
Other________________________					

6. From your experience in the construction field, to what extend could *a subcontractor's* problems during construction have been avoided and/or prevented by the factors listed below…..(If there are other factors that could have prevented cash problems, please list and evaluate in the spaces provided below). (5 = Completely, 4 = A good deal, 3 = A moderate amount, 2 = A small amount and 1 = Not at all)

Success Factors	5	4	3	2	1
Organization planning					
Project manager’s goal commitment					
Project team’s motivation and goal orientation					
Clarity of project scope and definition					
Project manager’s capability and experience					
Safety precautions and applied procedures					
Use of control system					
Other______________________					
Other________________________					
Other________________________					
Other________________________					

7. From your experience in the construction field, to what extend could ***an inadequate contractor experience*** during construction have been avoided and/or prevented by the factors listed below…..(If there are other factors that could have prevented cash problems, please list and evaluate in the spaces provided below). (5 = Completely, 4 = A good deal, 3 = A moderate amount, 2 = A small amount and 1 = Not at all)

Success Factors	**5**	**4**	**3**	**2**	**1**
Organization planning					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and definition					
Project manager's capability and experience					
Safety precaution and applied procedure					
The control system for this project					
Other______________________					
Other________________________					
Other________________________					
Other________________________					

Part 4. Additional Causes of Delay

From your experience, are there any other general causes of delay (not mentioned in the previous questions) that could have been avoided and prevented by either the listed success factors or others you have experienced?

1. Cause of delay: ________________________________could have avoided and/or prevented by:

Success Factors	**5**	**4**	**3**	**2**	**1**
Organization planning					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of the project scope and work definition					
Project manager's capability and experience					
Safety precautions and applied procedures					
Use of control system					
Other______________________					
Other________________________					
Other________________________					
Other________________________					

Part 4.Additional Cause of Delay

1 Cause of delay : ______________________________________could have avoided and/or prevented by:

Success Factors	5	4	3	2	1
Organization planning					
Project manager goal commitment					
Project team motivation and goal orientation					
Clarity of the project scope and definition					
Project manager capability and experience					
Safety precautions and applied procedures					
Use of control system					
Other______________________					
Other________________________					
Other________________________					
Other________________________					

Part 4. Additional Cause of Delay

Please reprint this page and attach it to the survey if you want to list more additional causes of delay

1.Cause of delay : ___________________________________could have avoided and/or prevented by:

Success Factors	**5**	**4**	**3**	**2**	**1**
Organization planning					
Project manager goal commitment					
Project manager motivation and goal orientation					
Clarity of project scope and definition					
Project manger capability and experience					
Safety precautions and goal orientation					
Use of control system					
Other_____________________					
Other_______________________					
Other_______________________					
Other_______________________					

Glossary of terms

- **Organization planning**: Development of a good project plan through judicious and adequate use of schedule networking techniques, scope and work definition, cash flow analysis, and risk identification.
- **Project manager goal commitment.**: The project manager's commitment to meeting cost, schedule, safety and quality commitments
- **Project team motivation and goal orientation**: The motivation of all the project personnel, particularly the supervisors, foremen, and field construction staff, with special reference to their commitment towards goals of the project.
- **Clarity of project scope and definition**: The project scope and work definition with special reference to completeness, clarity and changeability
- **Project manager capability and experience**: The project manager's experience and capabilities with particular reference to technical, administrative, human relations, and communication skills
- **Safety precaution**: All aspects of safety, with particular reference to the implementation of safety programs, monitoring of safety, safety regulations and requirements written into contract documents, and safety-linked bonus schemes
- **Use of Control system**: Procedures implemented to track project progress relative to goals established in the planning phase.
- **Lack of communication between parties:** 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 communication can lead to severe misunderstanding and therefore, delays in the execution of the project.

- **Owner's slow decision making**: The construction process was slowed by the owner's delay in approving construction material and completed work.
- **Change orders**: Change orders by owners during construction
- **Contractor's inadequate planning:** A contractor with inadequate experience cannot plan and manage the projects properly and this can lead to disastrous consequences
- **Owner's finance and payment of completed work:**. Work progress can be delayed due to late payments from the clients because there is inadequate cash flow to support construction expenses especially for those contractors who are not financially sound
- **Subcontractors:** Typically in huge projects, there are many subcontractors working under main contractors. If the subcontractor is capable, the project can be completed on time as planned. The project can be delayed if the subcontractor underperforms because of inadequate experience or capability.
- **Inadequate contractor's experience:** Contractor who has lack of experience and knowledge of construction work

APPENDIX I

LETTER FOR ROUND ONE DELPHI

CRITICAL SUCCESS FACTORS OF PROJECT MANAGEMENT IN BRUNEI BUILDING CONSTRUCTION INDUSTRY: IMPROVE PROJECT

Dear participant,
Thank you for your interest in my research to develop a strategy for the Building construction in Brunei. I value the unique contribution that you can make to my study.

You have been selected as a member of a panel of experts to participate in a two round questionnaire on the Brunei Building Construction. Your participation will involve questionnaire. The research methodology I am using is a qualitative one through which I am seeking comprehensive description of your experience in the Building construction. In this way I hope to answer my research question:

How could the Building construction in Brunei improve project delivery performance?

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 problem I am investigating. I am seeking solutions and strategies you think will be appropriate to avoid delay in Building construction in Brunei construction.

In the long term, this research could help the contract parties complete project on time and with highest quality. All the information you provide will kept in strict confidentiality and it will be only used for academic research. All comments and responses are kept anonymous.

There are no risks beyond normal day to day living associated with your participation of this project. I value your participation and thank you for the commitment of time, energy and effort. If you have any further questions, I can be reached at the address below.

Sincerely,

Rohaniyati Salleh
PhD candidate
Queensland University of Technology,
Brisbane, Queensland, 4001,
Australia.
Emails: r_salleh@hotmail.com
Emails: r_salleh@student.qut.edu.au

DELPHI QUESTIONNAIRE – ROUND ONE

PURPOSE

The purpose of this survey is to obtain the expert opinion on most important success factors that will help to avoid delay factors found in Brunei building construction.

INSTRUCTIONS

(Please review these instructions to understand the purpose of this survey and to be able to answer the questions.)This survey is divided in two rounds:

First round – please review the list of strategies and policies and rank their importance

Second round – the participants will be able to review the list of strategies

INSTRUCTION 1 – Please read the following definition

Critical Delay factors -	Critical success factors -
LACK OF COMMUNICATION BETWEEN PARTIES. 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. There are a lot of misunderstanding and problem of communication between parties..	**ORGANIZATION'S PLANNING EFFORT** Development of a good project plan through the judicious and adequate use of schedule networking techniques, scope and work definition, cash flow analysis, and risk identification
OWNER'S SLOW DECISION MAKING. The construction process was slowed by the owner's delay in approving construction material and completed work.	**PROJECT MANAGER'S GOAL COMMITMENT** The project manager's commitment to meeting cost, schedule, safety, and quality commitments.
CHANGE ORDERS. Change orders by owners during construction	**PROJECT TEAM'S MOTIVATION AND GOAL ORIENTATION** The motivation of all the project personnel, particularly the supervisors, foremen, and field construction staff, with special reference to their commitment towards the goals of the project.
CONTRACTOR'S INADEQUATE PLANNING. A contractor often fail to come out with practical and workable "work program" at the initial planning stage.	**CLARITY OF PROJECT SCOPE AND WORK DEFINITION** The project scope and work definition with special reference to completeness, clarity and changeability.
FINANCE AND PAYMENT OF COMPLETED WORK. The actual payments were made later than the contract-specified time	**PROJECT MANAGER'S CAPABILITIES AND EXPERIENCE** The project manager's experience and capabilities with particular reference to technical, administrative, human relations and communication skills
SUBCONTRACTORS. Typically in huge projects, there are many subcontractors working under main contractors. If the subcontractor is capable, the project can be completed on time as planned. The project can be delayed if the subcontractor underperforms because of inadequate experience or capability.	**SAFETY PRECAUTIONS AND APPLIED PROCEDURES** All aspects of safety, with particular reference to the implementation of safety programs, monitoring of safety, safety regulations and requirements written into contract documents, and safety-linked bonus schemes
INADEQUATE CONTRACTOR'S EXPERIENCE. Contractor who has lack of systematic site management and experience of construction work	**USE OF CONTROL SYSTEM** Procedures implemented to track project progress relative to goals established in the planning phase

INSTRUCTION 2 - Please give your details

Your position:

Years of experience:

Your contact address:

Your Email:

Qualification and achievement:

ROUND ONE – From your experience of Brunei construction development, please rank the critical success factors below in what you consider to be the level of need. 1 being the most needed and 7 being the least needed to avoid the delay factors of building construction in Brunei

	CRITICAL SUCCESS FACTORS	**RANKING**
I.	**ORGANIZATION'S PLANNING EFFORT** Development of a good project plan through the judicious and adequate use of schedule networking techniques, scope and work definition, cash flow analysis, and risk identification	
II.	**PROJECT MANAGER'S GOAL COMMITMENT** The project manager's commitment to meeting cost, schedule, safety, and quality commitments.	
III.	**PROJECT TEAM'S MOTIVATION AND GOAL ORIENTATION** The motivation of all the project personnel, particularly the supervisors, foremen, and field construction staff, with special reference to their commitment towards the goals of the project.	
IV.	**CLARITY OF PROJECT SCOPE AND WORK DEFINITION** The project scope and work definition with special reference to completeness, clarity and changeability.	
V.	**PROJECT MANAGER'S CAPABILITIES AND EXPERIENCE** The project manager's experience and capabilities with particular reference to technical, administrative, human relations and communication skills	
VI.	**SAFETY PRECAUTIONS AND APPLIED PROCEDURES** All aspects of safety, with particular reference to the implementation of safety programs, monitoring of safety, safety regulations and requirements written into contract documents, and safety-linked bonus schemes	
VII	**USE OF CONTROL SYSTEM** Procedures implemented to track project progress relative to goals established in the planning phase	

INSTRUCTION – PART 3 – Please indicate any additional success factors not presented in the previous list that you consider important to avoid critical delay factors in the Building construction in Brunei

THANK YOU

DELPHI ROUND TWO LETTER

Dear participant,

Thank you for your response to the first questionnaire and for your commitment to the process.

Your continued participation is critical. As we indicated in the beginning, this process involves a series of two rounds. Enclosed is the second round questionnaire based on what you and the other experts provided on the first round. We now need you to rank order the items to confirm their importance in view to other expert's opinions.

Please return your questionnaire to the email below.

I value your participation and thank you for the commitment of time, energy and effort. If you have any further questions, I can be reach at the address below.

Sincerely,

Rohaniyati Salleh
PhD candidate
Faculty of Building and Environment,
Queensland University of Technology,
Brisbane, Queensland, 4001,
Australia.
Email: r_salleh@qut.edu.au

DELPHI QUESTIONNAIRE – ROUND TWO

PURPOSE

The purpose of this survey is to obtain the expert opinion on most important critical success factors that will avoid delay factors in Building construction in Brunei.

The questionnaire question is to answer:

How could the Brunei Building construction improve deliver performance?

INSTRUCTION 1 – Please read the following definitions

Critical Delay factors -	**Critical success factors -**
LACK OF COMMUNICATION BETWEEN PARTIES. 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. There are a lot of misunderstanding and problem of communication between parties..	**ORGANIZATION'S PLANNING EFFORT** Development of a good project plan through the judicious and adequate use of schedule networking techniques, scope and work definition, cash flow analysis, and risk identification
OWNER'S SLOW DECISION MAKING. The construction process was slowed by the owner's delay in approving construction material and completed work.	**PROJECT MANAGER'S GOAL COMMITMENT** The project manager's commitment to meeting cost, schedule, safety, and quality commitments.
CHANGE ORDERS. Change orders by owners during construction	**PROJECT TEAM'S MOTIVATION AND GOAL ORIENTATION** The motivation of all the project personnel, particularly the supervisors, foremen, and field construction staff, with special reference to their commitment towards the goals of the project.
CONTRACTOR'S INADEQUATE	**CLARITY OF PROJECT SCOPE AND**

PLANNING. A contractor often fail to come out with practical and workable "work program" at the initial planning stage.	**WORK DEFINITION** The project scope and work definition with special reference to completeness, clarity and changeability.
FINANCE AND PAYMENT OF COMPLETED WORK. The actual payments were made later than the contract-specified time	**PROJECT MANAGER'S CAPABILITIES AND EXPERIENCE** The project manager's experience and capabilities with particular reference to technical, administrative, human relations and communication skills
SUBCONTRACTORS. Typically in huge projects, there are many subcontractors working under main contractors. If the subcontractor is capable, the project can be completed on time as planned. The project can be delayed if the subcontractor underperforms because of inadequate experience or capability.	**SAFETY PRECAUTIONS AND APPLIED PROCEDURES** All aspects of safety, with particular reference to the implementation of safety programs, monitoring of safety, safety regulations and requirements written into contract documents, and safety-linked bonus schemes
INADEQUATE CONTRACTOR'S EXPERIENCE. Contractor who has lack of systematic site management and experience of construction work	**USE OF CONTROL SYSTEM** Procedures implemented to track project progress relative to goals established in the planning phase

INSTRUCTION 2 –Please give your details

Position:

Your Email:

ROUND TWO – From your experience of Brunei building construction projects, please confirm your ranking of the policies below, base on other expert opinion, from 1 being the most needed and 7 being the least needed to deliver building construction project in Brunei.

CRITICAL SUCCESS FACTORS	EXPERT RANKINGS										CONFIRM YOUR RANKING
	A	B	C	D	E	F	G	H	I	J	
ORGANIZATION'S PLANNING EFFORT Development of a good project plan through the judicious and adequate use of schedule networking techniques, scope and work definition, cash flow analysis, and risk identification											
PROJECT MANAGER'S GOAL COMMITMENT The project manager's commitment to meeting cost, schedule, safety, and quality commitments.											
PROJECT TEAM'S MOTIVATION AND GOAL ORIENTATION The motivation of all the project personnel, particularly the supervisors, foremen, and field construction staff, with special reference to their commitment towards the goals of the project.											
CLARITY OF PROJECT SCOPE AND WORK DEFINITION The project scope and work definition with special reference to completeness, clarity and changeability.											
PROJECT MANAGER'S CAPABILITIES AND EXPERIENCE The project manager's experience and capabilities with particular reference to technical, administrative, human relations and communication skills											
SAFETY PRECAUTINS AND APPLIED PROCEDURES All aspects of safety, with particular reference to the implementation of safety programs, monitoring of safety, safety regulations and requirements written into contract documents, and safety-linked bonus schemes											
USE OF CONTROL SYSTEM Procedures implemented to track project progress relative to goals established in the planning phase											