PRODUCTIVITY ASSESSMENT AND SCHEDULE COMPRESSION INDEX FOR CONSTRUCTION PROJECT PLANNING

SHAIFUL AMRI BIN MANSUR

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy

Faculty of Civil Engineering
Universiti Teknologi Malaysia

DECEMBER 2004

To all who like to work smart.

ACKNOWLEDGEMENT

Alhamdulillah, I am very thankful to God that in preparing this thesis, I had received the support and assistance from many professionals from the construction industry, researchers, academicians, friends and family. Without their contributions, this thesis never would have come about. I express my deep appreciation to them:

- my supervisor, Associate Professor Dr Abd Hakim Mohammed for his advice, guidance and friendship;
- my ex-supervisor, Dr Che Wan Fadhil Che Wan Putra for his advice and friendship;
- UTM for the scholarship and opportunity given to me to study;
- my colleagues and friends for their supports and understandings;
- my wife for her complete support, encouragement and wisdom;
- my children for their patience, supports and prayers;

And finally, I also express my appreciation to many others whose contributions have made all the difference.

ABSTRACT

Productivity assessment and performance evaluation models identified from previous researches were normally performed separately to reduce complication and cost. However, performing both the productivity assessment and performance evaluation would benefit a project progress significantly. Furthermore, effective schedule compression methods should be identified to maximise productivity and reduce additional costs. The aim of the research was to develop a project management tool that combined productivity assessment and schedule compression methods for reporting productivity status and evaluating project performance. The report is produced based on the level of Factors Affecting Productivity (FAP) and Schedule Compression Methods (SCM) obtained from the project. The research was divided into three stages, which involved a pilot, first round, and second round questionnaire surveys. The respondents of the surveys were mostly project and site managers from registered construction firms in several states of the Malaysia Peninsular. The first stage of the research involved identifying the importance and optimum level of project planning, differences between productivity and performance, fundamentals of productivity assessments, plus FAP and SCM from literature review. The pilot survey was used to determine the relevance, suitability and applicability of the information obtained from literature review to the local building construction industry using index of importance method. The second stage of the research involved two rounds of surveys. The objective of the first round survey was to obtain the minimum and maximum limit for FAP and SCM elements weighting process, and to develop the questionnaire for second round survey. The objective of the second round survey was to obtain historical data from completed building construction projects. A table of predicted time performance ratio (TPR) was produced using fuzzy inference system, which was to be used as a project performance index table. The results showed that FAP and SCM were positively correlated, and so were FAP and TPR. In conclusions, there was a need for effective and cheaper project management tools. Productivity assessment and SCM were implemented only by less than fifty percent of the survey respondents. Correct selection of construction methods, scheduling implementation, starting work as planned, complexity of construction and contractor's budget allocation were considered as having high impact on FAP, while the most effective SCM claimed by the respondents was staffing the project with most efficient crew members. A status report that contained both productivity and performance status of a project was successfully produced.

ABSTRAK

Beberapa model bagi penaksiran produktiviti dan penilaian prestasi yang dikenal pasti dari kajian lepas pada kebiasaannya telah dilaksanakan secara berasingan untuk mengurangkan komplikasi dan kos. Namun begitu, melaksanakan kedua-dua penaksiran produktiviti dan penilaian prestasi akan meningkatkan kemajuan projek. Tambahan lagi, kaedah pemendekan jadual yang berkesan perlu dikenal pasti untuk memaksimumkan produktiviti dan mengurangkan kos tambahan. Tujuan kajian ini adalah untuk mengorak satu alat pengurusan projek yang menggabungkan penaksiran produktiviti dan penilaian prestasi bagi melaporkan status produktiviti dan menilai prestasi projek. Laporan itu dibuat berdasarkan tahap faktor mempengaruhi produktiviti (FAP) dan kaedah pemendekan jadual (SCM) yang diperolehi dari projek. Kajian ini terbahagi kepada tiga peringkat, iaitu tinjauan pandu, pusingan pertama dan pusingan kedua. Peserta kajian yang paling ramai menjawab adalah pengurus projek dan pengurus tapak dari syarikat pembinaan yang berdaftar di beberapa negeri di Semenanjung Malaysia. Peringkat pertama kajian adalah untuk mengenal pasti kepentingan dan perancangan projek yang optimum, perbezaan produktiviti dengan prestasi, asasi bagi penaksiran produktiviti, termasuk FAP dan SCM dari kajian literatur. Tinjauan pandu digunakan bagi menentukan perkaitan, kesesuaian dan keboleh gunaan maklumat yang diperolehi dari kajian literatur terhadap industri pembinaan bangunan tempatan dengan menggunakan kaedah indeks penting. Tahap kedua kajian melibatkan dua pusingan tinjauan. Objektif bagi tinjauan pusingan pertama adalah untuk mendapatkan had minimum dan maksimum bagi proses mengira berat untuk elemen FAP dan SCM, dan mengorak soal selidik bagi tinjauan pusingan kedua. Objektif bagi tinjauan pusingan kedua adalah untuk mendapatkan data dari projek pembinaan bangunan yang telah siap. Satu jadual nisbah prestasi masa (TPR) ramalan telah dihasilkan dengan menggunakan sistem taabir *fuzzy*, untuk dijadikan jadual indeks prestasi projek. Keputusan telah menunjukkan bahawa FAP dan SCM bersekaitan positif, sama seperti FAP dan TPR. Sebagai kesimpulan, terdapat keperluan bagi alat pengurusan projek yang berkesan dan lebih murah. Penaksiran produktiviti dan SCM hanya dilaksanakan oleh kurang daripada lima puluh peratus dari keseluruhan peserta yang menjawab. Pilihan kaedah pembinaan yang tepat, perlaksaan penjadualan, memulakan kerja seperti yang terjadual, kesukaran pembinaan dan pengagihan bajet kontraktor telah dikatakan mempunyai impak yang besar ke atas FAP, manakala SCM yang dikatakan paling berkesan oleh peserta yang menjawab adalah mendapatkan pekerja projek yang paling cekap. Laporan status yang mengandungi kedua-dua status produktiviti dan prestasi projek telah berjaya dihasilkan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS/ABBREVIATIONS/NOTATIONS/TERMINOLOGIES

ACWP	-	Actual Cost of Work Performed
AHP	-	Analytical Hierarchy Process
ANFIS	-	Adaptive Neuro-Fuzzy Inference System
BCIS	-	Building Cost Information Service
BCWP	-	Budgeted Cost of Work Performed
BCWS	-	Budgeted Cost of Work Scheduled
CDF	-	Cumulative Distribution Functions
CICE	-	Construction Industry Cost Effectiveness Project
CII	-	Construction Industry Institute of America
CPM	-	Critical Path Method
CPF	-	Cost Performance Factor
CPI	-	Cost Performance Index
CPU	-	Cost per Unit
CSF	-	Critical Success Factors
CV	-	Cost Variance
DEA	-	Data Envelopment Analysis
DI	-	Disruption Index
EMR	-	Experience Modification Ratings
EPC	-	Engineer-Procure-Construct
EV	-	Earned Value
FAP	-	Factors Affecting Productivity
FIS	-	Fuzzy Inference System
FMEA	-	Failure Mode And Effect Analysis
GA	-	Genetic Algorithms
GPM	-	General Performance Model

GUI	-	Graphical User Interface
KPIs	-	Key Performance Indicators
MCS	-	Monte Carlo Simulation
MF	-	Membership Functions
MLGAS	-	Machine Learning and Genetic Algorithms based System
OCV	-	Original Contract Value
PASCI	-	Productivity Assessment And Schedule Compression Index
PDCA	-	Plan-Do-Check-Act
PDF	-	Probability Density Functions
PDRI	-	Project Definition Rating Index
PERT	-	Program Evaluation and Review Technique
PMI	-	Project Management Index
PPC	-	Percent Of Planned Completed
PR	-	Performance Ratio
R	-	Pearson Correlation Coefficient
R-square	-	Coefficient Of Determination
SCM	-	Schedule Compression Methods
SPF	-	Schedule Performance Factor
SPI	-	Schedule Performance Index
SV	-	Schedule Variance
TFP	-	Total Factor Productivity
TPR	-	Time Performance Ratio
TQM	-	Total Quality Management
UMH	-	Unit per Man-Hour
VTR	-	Videotapes Recording
a_i	-	Weight Value
e_i	-	Residual For The i^{th} Observation In The Data Set
i	-	Response Index
n	-	Total Respondents
t_e	-	Expected Performance Time
x	-	List Of Explanatory Variables
x_i	-	i^{th} Frequency Of Response
y_i	-	i^{th} Response In The Data Set
C_t	-	Total Value Of Change Orders

E	-	Expected Project Performance Time
I	-	Index Of Importance
Y_i	-	Given Data Set
V_T	-	Variance In Total Project Performance
β	-	Parameters Estimated During Modeling Process

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Construction projects are one-time and largely unique efforts of limited duration, which involve work of a non-standardised and variable nature. Field construction works can be greatly affected and influenced by events that are difficult to anticipate. High cost requirements and limited time to adjust can seriously worsen the situation. Proper co-ordination and communication can have significant effect on productivity and quality of construction projects (Sadri, 1994). This makes skilled and unremitting management efforts become not only desirable but also imperative for a satisfactory result. There is just too much risk to undertake a construction project without a well-thought plan. The risks can emerge in the forms of time variation, cost variation or litigations.

Productivity is one of the most important basic variables governing economic production activities (Alby, 1994). However, despite being so important, productivity has sometimes been relegated to second rank, neglected or ignored. In recent years, the pressures of an increasingly global economy have compelled companies in all industries including construction to focus on strategies for productivity improvements. Unfortunately, issues related to productivity measurement or assessment have not received adequate attention by the relevant parties. The main reasons that made productivity assessment become complicated were (Belcher and John, 1984; Alby, 1994; Sudit, 1995):

- *Methodology*: Improvements in the methodology of productivity assessment were diversified and not performed as a whole.
- *Operational*: The implementations of productivity assessment procedures in most firms were not adequate.

Nevertheless, many construction development bodies have shown interest in the study of productivity in the construction industry. Over the past several years, the Construction Industry Institute of America (CII) has funded a number of research projects focused on productivity (CII, 1990a; CII, 1992; CII, 1994a; CII, 1994b). Findings from these investigations have somehow changed the degree of awareness of project management professionals toward the importance and benefits of productivity assessment.

There are two common problems related to the productivity issues. The first common problem faced by clients and contractors is project delay (Finke, 1999; Kartam, 1999; Al-Hammad, 2000). A project delay means a project that cannot be completed, partially or as a whole, on or before the scheduled completion date. There are many factors that can delay works and the project completion, such as unexpected events, hidden conditions or even additional work assigned during construction. In order to bring the project back on schedule, the contractor's rate of performing the remaining activities must be increased because there is more work to be finished in a limited time. Even though the whole project schedule may look the same, the contractor's individual schedule may have to be compressed.

The second problem, which usually troubles the contractor, is when the client decides to move in or use a facility earlier than planned, which makes the whole project schedule needs to be completed early (AGC, 1994; Al-Khalil and Al-Ghafly, 1999). This may involve shortening or compressing the overall schedule duration by revising the project plan. Schedule compression can be performed during the planning process before the start of construction or anytime in between the construction period (CII, 1988a & 1990b). The usual goal of schedule compression to the client is to shorten the overall schedule duration by the necessary amount at the least cost (AGC, 1994).

In both cases, productivity aspects of the project must be understood, so that productivity can be increased and effective methods of schedule compression can be applied in order to complete a construction project at the required time with least costs (CII, 1990b). Measuring project performance alone will not be very effective because the sources of improving performance come from productivity control and improvement, which cannot be done without productivity assessment (Allmon *et al.*, 2000). In general, productivity assessment can provide an objective source of information about operating trends, draw attention to problems of performance and inspire a useful exchange of ideas.

1.2 Background of the Problem

It is the norm that all project participants would attempt to perform well when a construction project is first undertaken (McKim *et al.*, 2000). However, construction projects must go through many complex steps, difficult site conditions and different individuals, which have caused some unavoidable delays, such as changing of the planned concepts or even rescheduling the project details (Faniran *et al.*, 1999). It is highly desirable for contractors to deal with productivity objectively (Paulonis and Cox, 2003). Project managers and participants should implement techniques that are aimed at "doing things right the first time" and able to find, analyse and make corrections while the job is under way (Daffenbaugh, 1993; Jahren and Federle, 1999; Deming, 1986). Thus, there must be some appropriate ways to monitor tasks from deviations and to bring the schedule back on track when problems occur or delays happen.

An extensive literature review was performed on related topics, such as pre-project planning (Gibson and Hamilton, 1994; Gibson *et al.*, 1993; Gibson *et al.*, 1994; CII, 1995; CII, 1997), productivity (Motwani *et al*., 1995; Thomas and Zavrski, 1999; Allmon *et al.*, 2000; Rojas and Aramvareekul, 2003a; Rojas and Aramvareekul, 2003b; Goodrum and Hass, 2004), schedule compression (Moselhi, 1993; Noyce and Hanna, 1998; CII, 1988, 1990 & 1998; Hanna *et al*., 1999a & 1999b) and project success (Chan *et al*., 2001; Griffith *et al*., 1999; Chua, 1999; Griffith and Gibson, 2001; Gao *et al*., 2002). The findings were used to provide background and support in developing the problem statement and methodology used in this study.

According to a study by CII (1994c), pre-project and project planning are very important in determining the success of a project. The better it is performed, the better the overall outcome of the project would be. In other words, there is a positive, quantifiable relationship between effort expended during the pre-project planning phase and the ultimate success of a project (Ottoman *et al.*, 1999; McKim *et al*., 2000; Cox *et al.*, 2003). By establishing lower third, middle third and upper third pre-project planning effort groups within the sample and evaluating each group against success variables, some broad conclusions can be made. At least, various parties involved in construction projects should understand the implications of pre-project planning in terms of project execution and the contracting environment that currently exists in the industry.

Many public and private sectors are investing significantly less money into preventive maintenance programmes in the construction industry. This lack of financial commitment towards construction projects is because of construction productivity and quality has not improved as much as in other industries and is regarded as low-priority investment (Christian and Hachey, 1995). However, the practice of giving low commitment to productivity and quality improvement should not be continued further because a successful project implementation should be accepted as a big return of an investment too.

1.3 Statement of the Problem

Delays in construction projects are very common, but not something that are unavoidable (Finke, 1999; Kartam, 1999; Carr, 2000). When delay happens, work output or productivity must be increased so that the initial schedule can be achieved. Although there are many methods suggested and commonly used to accelerate work productivity or to compress construction schedules, there is no clear and definitive answer on the effects of these method on certain important characteristics of a project, such as the capability of increasing the productivity rate of labour, reducing the schedule duration and whether the methods selected will increase the project costs (Christian and Hachey, 1995; Motwani, 1995; Noyce and Hanna, 1998; Crockett, 2000; Allmon *et al.*, 2000, Marsh, 2002; Rojas and Aramvareekul, 2003a). For example, the initial reaction for most cases is probably to use more labour, increase the work period into overtime or use an additional shift (Noyce and Hanna, 1998). Yet, it is not clear if these methods will in fact reduce the duration and what the overall impact on cost will be. On the other hand, there are also many other schedule compression methods that are not commonly considered as equally or more effective in reducing the impacts on the financial status of contractors during schedule compression period (CII 1990).

However, there have been many studies performed and models developed by researchers in other countries that can be used as guides to this research (Perera, 1982; Coskunogula, 1984; Vrat and Kriengkrairut, 1986; Ritchie, 1990; CII, 1990; Moselhi, 1993; Senouci and Hanna, 1995; Noyce and Hanna, 1998). Some of the major problems with those existing models are that they have to be specially tailored or customised to the project local needs before they can be applied effectively (Hancher and Abd-ElKhalek, 1998). They can also be too complex to be understood and applied by general construction parties because they generally lack the emphasis and accountability on practical and effective concepts or the methods used in compressing the construction schedule itself (Thomas *et al.*, 1999; Han and Diekmann, 2001).

Contractors and clients must be able to identify their resource constraints and apply the appropriate management decision process in the selection of the schedule compression approach or technique (Leu *et al.*, 1999; Chelaka *et al.*, 2001; Hegazy and Ersahin, 2001). There is a need to assess and evaluate the current or expected level of productivity and to identify the most effective methods of getting a project back on track. The need is to develop an improvised model of productivity assessment and schedule compression methods that is simple to understand and easy to apply, so that contractors and clients can be guided and informed about how to increase productivity and compress a schedule effectively with very little time to prepare and anticipate. The primary purpose of this study is to develop a practical tool or index that can be used by Malaysian project planning teams, including contractors and clients.

1.4 Aim and Objectives

The aim of the research is to develop a project management tool that combines productivity assessment and schedule compression methods for reporting productivity status and evaluating project performance. The objectives of this research are:

1. To establish the level of implementation of:
   a. Project planning.
   b. Productivity assessment.
   c. Schedule compression methods.

2. To identify elements of the followings that are relevant to the local building construction projects:
   a. Factors affecting productivity.
   b. Schedule compression methods.
3. To determine the correlations between factors affecting productivity, schedule compression methods and project time performance.

4. To perform productivity assessment and performance evaluation using single planning tool.
5. To compare estimated risks involved with and without productivity assessment tool.

1.5 Scope of Research

The chance of achieving a project success can be increased by performing assessment on project productivity and on the effectiveness of schedule compression methods. This is done by forecasting the probability in which certain construction activity will finish on time and the capability of compressing the project schedule. Because of insufficient project data and the requirement of additional planning costs, pre-project planning was typically not given enough emphasis in building construction projects in Malaysia. Therefore, an inexpensive management or planning tool that can be applied during pre-project and construction stage can be very useful, especially the one that is user-friendly, accurate and reliable.

In developing such a tool, a study was conducted to gather data on general building projects in Peninsular Malaysia that were completed within the last five years. The tool was developed and intended to be used in general building construction projects, such as schools, offices, shop-houses, hotels, residential, mosques and institutional buildings. In order to avoid significant discrepancies, the tool should be limited from being applied in other types of projects or in other countries.

1.6 Methodology of the Research

Figure 1.1 represents the methodology of the research, which was performed over a three years and six months period. The study was divided into stages, namely, the first, second and third stage. The first stage involved collecting data from literature review, setting research aims and objectives, and conducting a pilot survey. The second stage involved two rounds of survey, model fitting and data analyses. The third stage involved model validation, risk prediction, conclusion and recommendations for future research.

The initial steps in the first stage was identifying the importance and optimum level of project planning, the differences between productivity and performance, fundamentals of productivity assessments, Factors Affecting Productivity (FAP) and Schedule Compression Methods (SCM) from previous research found in the literature review. This was followed by a pilot survey, which objective was to determine the relevance, suitability and applicability of the information obtained from literature review to the local building construction industry using index of importance method.

In the second stage, the objective of the first round survey were to obtain the minimum and maximum limit for FAP and SCM elements weighting process, and develop the questionnaire for second round survey. The objective of the second round survey was to obtain historical data from completed projects. The data were analysed to determine the correlations between FAP, SCM and TPR. Once the correlations were determined, a prediction table for predicted TPR values was produced using fuzzy inference system. The table of predicted TPR values can be referred to as the project performance index table.

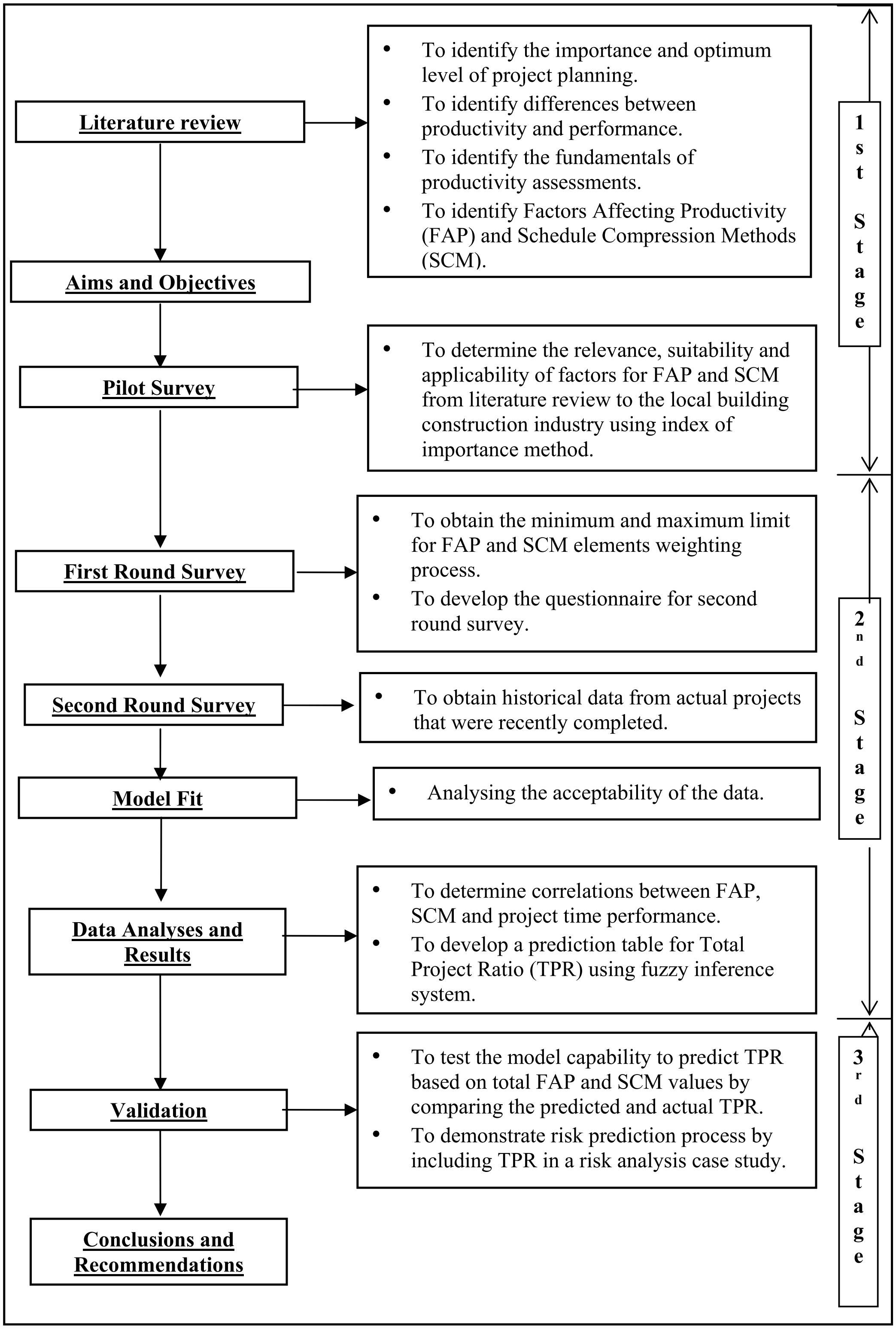

Figure 1.1 : Methodology of the research

In the third stage, validation of the data was performed to test their accuracy and consistency. The predicted TPR values were validated using completed project data. An application of risk analysis was also demonstrated for an on-going project at the time of the research, as a case study. Lastly, conclusions of the research and recommendations for future research were made. More details on the research methodology can be found in Chapter 6.

1.7 Organisation of the Thesis

This thesis is divided into ten chapters. Chapter 1 gives the introduction and background to the existing problems, describes the research objectives and the research methodology.

Chapter 2 provides the overview of project planning. The importance of implementing and finding the correct level of planning are discussed. The existing planning models are identified.

Chapter 3 highlights the difference between productivity and performance. Existing performance measurement and performance indicators are identified.

Chapter 4 focuses on productivity assessment process. Methodologies for direct and indirect productivity assessment are identified. Factors affecting productivity are also identified, which are important to the development of the research.

Chapter 5 identifies productivity and schedule compression methods that have been developed and implemented in previous research. The strengths and limitations of the models are described.

Chapter 6 discusses in detail the methodology of the research. The research was discussed in accordance to stages of the research. Identification of survey elements, questionnaire development, data collection process and method of analysis are the main topics described in the chapter.

Chapter 7 describes the analyses that were performed on the data collected from different stages of the research. The results are displayed, analysed and discussed in order to obtain significant findings and fulfill the research objectives.

Chapter 8 discusses the data validation process. The model capabilities in performing productivity assessment and performance evaluation are demonstrated using data from completed projects. Actual project data were compared to the predicted values produced in this research.

Chapter 9 demonstrates the application of the research findings in predicting and reducing project risks. The demonstration is performed on a selected project as a case study.

Chapter 10 finally summarises the research work, provides the conclusions of this research and recommendations for future research.

e) Different versions of the PASCI namely for building, industrial and infrastructure projects are also recommended. The existing methodology and data should significantly reduce the research efforts of developing a new version of the PASCI.

f) Enhancing the application using information technology or other new technology can widen the interest in the application of this tool.

REFERENCES

Ab-Hamid, M. (1992). *Influence of Wall Panel Characteristics on the Productivity of Bricklayers*. University of Dundee: Ph.D. Thesis.

Abbasi, G. Y. and Mukattash, A. M. (1999). Crashing PERT Networks Using Mathematical Programming. *International Journal of Project Management*. 19: 181-188.

Abd-Kadir, M. R. (2003). Productivity Insights. *Housing and Construction News*. 5(1): 4-5.

Abd-Majid, M. Z. (1997). Non-Excusable Delays in Construction. Loughborough University: Ph.D. Thesis.

Abd. Majid, M. Z., and McCaffer, R. (1996). Critical Factors that Influence Schedule Performance. *Productivity in Construction – International Experiences*. 2nd International Congress in Construction. Singapore. 73–79.

Abd. Majid, M. Z., and McCaffer, R. (1998). Factors of Non-Excusable Delays That Influence Contractors Performance. *Management in Engineering.* 14(3): 42–49.

Abdelhamid, T. S. and Everett, J. G. (1999). Physiological Demands of Concrete Slab Placing and Finishing Work. *Construction Engineering and Management*. 125(1): 47-52.

Abeysinghe, G. and Urand, D. (1999). Why Use Enactable Models of Construction Processes ? *Construction Engineering and Management*. 125(6): 437-447.

AbouRizk, S., Knowles, P. and Hermann, U. R. (2001). Estimating Labor Production Rates for Industrial Construction Activities. *Construction Engineering and Management*. 127(6): 502-511.

Ackoff, R. L. (1970). *A Concept of Corporate Planning*. New York: Wiley.

Aft, L. S. (1992). *Productivity Assessment and Improvement*. 2nd Edition. New York: Prentice Hall.

AGC. (1994). *Construction Planning and Scheduling*. Publication No. 1107.1.

Ahuja, H. M. and Arunachalam, V. (1984). Risk Evaluation in Resource Allocation. *Construction Engineering and Management*. 110(4): 324-336.

Akel, N., Ashley, D., Tsai, C. C. and Teicholz, P. (1996). *Computer Implementation of The Impact of Early-Planning Decisions On Project Performance*. University of California: Working paper.

Al-Hammad, A. M. (2000). Common Interface Problems Among Various Construction Parties. *Performance of Constructed Facilities*. 14(2): 71-74.

Al-Khalil, M. I. and Al-Ghafly, M. A. (1999). Delay in Public Utility Projects in Saudi Arabia. *International Project Management*. 17(2): 101-106.

Alarcon, L. F. and Ashley, D. B. (1996). Modeling Project Performance for Decision Making. *Construction Engineering and Management*. 122(3): 265-273.

Alarcon, L. (1997). *Lean Construction*. The Netherlands: A. A. Balkema.

Alarcon, L. F., Venegas, P., Bastyas, A. and Campero, M. (1997). Identification of Critical Factors in the Client-Contractor Relationship. In: Alarcon eds. *Lean Construction*. Rotterdam: Balkema. 127-142.

Alarcon, L. F., and Ashley, D. B. (1998). Project Management Decision Making Using Cross-Impact Analysis. *International Project Management*. 16(3): 145-152.

Alarcon, L. F. and Ashley, D. B. (2000). *Assessing Project Execution Strategies for Embassy Projects*. U.S. Dept. of State: FBO Report.

Alarcon, L. F. and Bastias, A. (2000). A Computer Environment to Support the Strategic Decision-Making Process in Construction Firms. *Architectural Engineering and Management*. 7(1): 63-75.

Alarcon, L. F. and Mourgues, C. (2002). Performance Modeling for Contractor Selection. *Management in Engineering*. 18(2): 52-60.

Alby, V. (1994). Productivity: Measurement and Management. *Transactions of AACE International*. 1994: MAT4.1-4.7.

Alfeld, L. E. (1988). *Construction Productivity, On-Site Measurement and Management*. New York: McGraw-Hill.

Allmon, E., Haas, C. T., Borcherding, J. D. and Goodrum, P. M. (2000). U.S. Construction Labor Productivity Trends, 1970–1998. *Construction Engineering and Management*. 126(2): 97-104.

Alsakini, W., Wikstro, K. and Kiiras, J. (2004). Proactive Schedule Management of Industrial Turnkey Projects in Developing Countries. *International Project Management*. 22: 75–85.

Aouad, G. and Alshawi, M. (2000). *Construction Integrated Environments Workbook*. University of Salford: Masters Level Module –Integrated Environments and CAD. 7.2-7.4

Arditi, D. (1985). Construction Productivity Improvement. *Construction Engineering and Management*. 111(1): 1–14.

Armentrout, D. R. (1986). Engineering Productivity Management and Performance Measurement. *Management in Engineering*. 2(3): 141-147.

ASCE (2000). *Quality in the Constructed Project: A Guide for Owners, Designers, and Constructors*. American Society of Civil Engineers. 2nd Ed. VA: Reston.

Ashley, D. B., Jaselskis, E. J. and Laurie, C. S. (1987). The Determinants of Construction Project Success. *Project Management*. 18(2): 69-79.

Asma, A. (1992). *Understanding the Malaysian Workforce – Guidelines for Managers*. Malaysian Institute of Management. Kuala Lumpur.

B&I. (2004). *Budget 2005 – Highlight for the Building Industry*. Building and Industry. 14(3).

Back, W. E., Maxwell, D. A. and Isidore, L. J. (2000). Activity-Based Costing as a Tool for Process Improvement Evaluations. *Management in Engineering*. 16(2): 48-58.

Back, W. E. and Moreau, K. A. (2000). Cost and Schedule Impacts of Information Management on EPC Process. *Management in Engineering*. 16(2): 59-70.

Baker, B. N., Murphy, D. C. and Fisher, D. (1983). *Factors Affecting Project Success*. In: D. I. Cleland and W. R. King, eds. Project Management Handbook, New York: Van Nostrand Reinhold. 669-685.

Ballard, G. and Howell, G. (1994a). Lean Production Theory: Moving Beyond Can-Do. *Proceedings*. *2nd Annual Conference on Lean Construction*. Sept. Pontificia Universidad Catolica de Chile. http://www.vtt.fi/rte/lean/santiago.htm. Reprinted in Alarcon (1997).

Ballard, G., and Howell, G. (1994b). Implementing Lean Construction: Improving Downstream Performance. *Proceedings*. *2nd Annual Conference on Lean Construction*. Sept. Pontificia Universidad Catolica de Chile. http://www.vtt.fi/rte/lean/santiago.htm. Reprinted in Alarcon (1997).

Ballard, G. and Howell, G. (1998). Shielding Production: An Essential Step in Production Control. *Construction Engineering and Management*. 124(1): 18-24.

Barber, P., Graves, A., Hall, M., Sheath, D., and Tomkins, C. (2000). Quality Failure Costs in Civil Engineering Projects. *International Quality and Reliability Management*. 17(4/5): 479–492.

Barraza, G. A., Back, W. E. and Mata, F. (2000). Probabilistic Monitoring of Project Performance Using SS-Curves. *Construction Engineering and Management*. 126(2): 142-148.

Barrie, D. S., and Paulson, B. C. (1992). *Professional Construction Management*. New York: McGraw-Hill.

Baumol, W. and Maddela, G. (1990). Quality Changes and Productivity Measurement: Hedonics and Alternative Professional Adaptation Discussion. *Accounting, Auditing and Finance*. 5(1): 105-24.

BCIS. (1988). *Tender Sum/Final Account Study*. Building Cost Information Service News. London: Royal Institution of Chartered Surveyors. 25.

Belcher, Jr. and John, G. (1984). *The Productivity Management Process*. Houston: American Productivity Center.

Bhurisith, I. and Touran, A. (2002). Case Study of Obsolescence and Equipment Productivity. *Construction Engineering and Management*. 128(4): 357-361.

Biema, M. V. and Greenwald, B. (1997). Managing Our Way to Higher Service-Sector Productivity. *Harvard Business Review*. July-August: 87-95.

Bohrnstedt, G. W., and Knoke, D. (1994). *Statistics for Social Data Analysis*. 3rd Ed. Illinois: F.E. Peacock Publishers.

Bojadziev, G., and Bojadziev, M. (1997). *Fuzzy Logic for Business, Finance and Management*. Singapore: World Scientific.

Borcherding, J. D. and Alarcon, L. F. (1991). Quantitative Effects on Construction Productivity. *The Construction Law*. 11: 1-48.

Burati, J. L., Farrington, J. J. and Ledbetter, W. B. (1992). Causes of Quality Deviations in Design and Construction. *Construction Engineering and Management*. 118(1): 34-49.

Burton, F. (1991). A Methodology for Measuring Construction Productivity. *American Association of Cost Engineers Transactions*. L3: 1-4.

Carr, R. I. (2000). Construction Congestion Cost (CO^3) Basic Model. *Construction Engineering and Management*. 126(2): 105-113.

Caves, D. W., Christensen, L. R. and Diewert, W. E. (1982). The Economic Theory of Index Numbers and the Measurement of Input, Output and Productivity. *Econometric*. 50(6): 1939-1414.

Chambers, J., Cleveland, W., Kleiner, B. and Tukey, P. (1983). *Graphical Methods for Data Analysis*. Florida: Wadsworth.

Chan, A. P. C., Yu, A. T. W., and Tam, C. M. (1999). Enhanced Design Build: An Innovative System to Procure a Hospital Project. *Proceedings*. *CIB W92 and CIB TG23 Profitable Partnering in Construction: Procurement, Procurement System and Culture in Construction*. *Joint Symposium*. 405–415.

Chan, A. P. C., Ho, D. C. K. and Tam, C. M. (2001). Design and Build Project Success Factors: Multivariate Analysis. *Construction Engineering and Management*. 127(2): 93-100.

Chang, L.M. (1986). Inferential Statistics for Craftsman Questionnaire. *Construction Engineering*. 112(4): 13-29.

Chang, L.M. and Borcherding, J.D. (1986). Craftsman Questionnaire Sampling. *Construction Engineering*. 112(4): 543-556.

Chang, L. (1991). A Methodology for Measuring Construction Productivity. *Cost Engineering*, 3(10): 19-25.

Chang, A. S. (1997). *Consultant Performance Measurement and Evaluation for On-Call Projects*. University of California Berkeley: Ph.D. dissertation.

Chang, A. S. and Ibbs, C. W. (1998). Development of Consultant Performance Measures for Design Projects. *Project Management*. 29(2): 39-54.

Chang, A. S-T. (2001). Defining Cost-Schedule Performance Indices and Ranges for Design Projects. *Management in Engineering*. 17(2): 122-130.

Chau, K. W. and Walker, A. (1988). The Assessment of Total Factor Productivity of the Hong Kong Construction Industry. *Construction and Production Economics*. 6(3): 209-224.

Chelaka, M., Abeyasinghe, L., Greenwood, D. J. and Johansen, D. E. (2001). An Efficient Method for Scheduling Construction Projects with Resource Constraints. *International Project Management*. 19: 29-45.

Cheng, R. T. L. (1995). Design and build: contractors role. *Proceeding, Design and Build Projects: International Experiences, International Congress on Construction*: 232–241.

Cheng, E. W. L., Li, H. and Love, P. E. D. (2000). Establishment of Critical Success Factors for Construction Partnering. *Management in Engineering*. 16(2): 84-92.

Cheng, R. and Gen, M. (2001). *Production Planning and Scheduling Using Genetic Algorithms*. Computational Intelligence in Manufacturing Handbook. Boca Raton: CRC Press LLC.

Chevalier, N. J. and Russell, A. D. (2001). Developing a Draft Schedule using Templates and Rules. *Construction Engineering and Management*. 127(5): 391-398.

Chistester, D. (1992). A Model for Analyzing Jobsite Productivity. *American Association of Cost Engineers Transactions*. 1(1): c31-35.

Cho, C. S., Furman, J. C., and Gibson, G. E. (1999). *Development of the Project Definition Rating Index (PDRI) for Building Projects*. University of Texas at Austin: Prepared for Construction Industry Institute. Resource Report. 155-11.

Cho, C. S. (2000). *Development of the Project Definition Rating Index (PDRI) for Building Projects*. University of Texas at Austin: PhD thesis.

Cho, C-S. and Gibson Jr., G.E. (2001). Building Project Scope Definition Using Project Definition Rating Index. *Architectural Engineering*. 7(4): 115-125.

Choo, H. J., Tommelein, I. D., Ballard, G. and Zabelle, T. R. (1999). Workplan: Constraint-Based Database for Work Package Scheduling. *Construction Engineering and Managemen*t. 125(3): 151-160.

Christian, J. and Hachey, D. (1992). Production Rates in Construction. *Procurement Conference*. Quebec City: Canadian Society for Civil Engineering.

Christian, J. and Hachey, D. (1995). Effects of Delay Times on Production Rates in Construction. *Construction Engineering and Management*. 121(1): 20-26.

Chua, D. K. H., Kog, Y. C. and Loh, P. K. (1999). Critical Success Factors for Different Project Objectives. *Construction Engineering and Management*. 125(3): 142-150.

CIDB (2004). *The CIDB Directory 2004-2005 - The Nation's Builders, Contractors, Construction Materials, Plants and Equipment Construction Industry Directory*. Construction Industry Development Board. Malaysia. Bi-annual Report.

CII (1988a). *Concepts and Methods of Schedule Compression*. Construction Industry Institute. University of Texas at Austin. Publication 6-7.

CII (1988b). *Project Control for Engineering*. University of Texas at Austin: Bureau of Engineering Research. Publication No. 6-1.

CII (1990a). *Productivity Measurement: An Introduction*. Construction Industry Institute. University of Texas at Austin. Publication 2-3.

CII (1990b). *Concepts and Methods of Schedule Compression*. Construction Industry Institute. University of Texas at Austin. Source Document 55.

CII (1992). *An Assessment of Education and Training Needs Among Construction Personnel*. Construction Industry Institute. University of Texas at Austin. Special Publication 14-2.

CII (1994a). *Effects of Scheduled Overtime on Labor Productivity: A Quantitative Analysis*. Construction Industry Institute. University of Texas at Austin. Source Document 98.

CII (1994b). *The Effects of Change on Labor Productivity: Why and How Much?* Construction Industry Institute. University of Texas at Austin. Source Document 99.

CII (1994c). *Pre-Project Planning: Beginning a Project the Right Way*. Construction Industry Institute. University of Texas at Austin. Publication 39-1.

CII (1995). *Pre-Project Planning Hand-Book*. Construction Industry Institute. Austin. University of Texas at Austin. Special Publication 39-2.

CII (1996). *PDRI: Project Definition Rating Index, Industrial Projects*. Construction Industry Institute. University of Texas at Austin. Implementation Resource. 113-2.

CII (1997). *Alignment during Pre-project Planning*. Construction Industry Institute. University of Texas at Austin. Implementation Resource. 113-3.

CII (1998). *Cost and Schedule Impacts of Information Management*. Construction Industry Institute. University of Texas at Austin. Research summary 125-1.

Cleland, D. I. (1986). Measuring Success: The Clients Viewpoint. *Procurement*. Montreal: Project Management Institute. 6-12.

Cole, L. J. R. (1991). Construction Scheduling: Principles, Practices and Six Case Studies. *Construction Engineering and Management*, 117(4): 579.

Conepari, J. E., and Varrone, M. J. (1995). Application of a Manual Earned Value System for Small Engineering Projects. *Transactions*. *American Association of Cost Engineers*. June 30: A-3.

Conrow, E. H. (2003). *Effective Risk Management: Some Keys to Success*. 2nd Ed. VA: Reston.

Coskunogula, O. (1984). Optimal Probabilistic Compression of PERT Networks. *Construction Engineering and Management*. 110(4): 437-446.

Cowie, G. F. and Carr, J. P. (1984). Discussion of Integrated Project and Process Management by Cowie and Carr. *Construction Engineering and Management*. 110: 121-122.

Cox, R. F., Issa, R. R. A. and Ahrens, D. (2003). Managements Perception of Key Performance Indicators for Construction. *Construction Engineering and Management*. 129(2): 142-151.

Crandall, K. C. (1977). Analysis of Schedule Simulations. *Construction Division*. 103(3): 387-394.

Crockett, G. V. (2000). *Can We Explain Australian Labour Productivity Growth? Some Evidence from AWIRS*. School of Economics and Finance. Curtin University of Technology. 1-44.

Daffenbaugh, R. L. (1993). Total Quality Management at Construction Jobsites. *Management in Engineering*. 9(4):382–389.

Danladi, S. K., and Horner, R. M. W. (1981). Management Control and Construction Efficiency. *Construction Division*. Proceedings of American Society of Civil Engineers. 107(C-04): 705-718.

Darwiche, A., Levitt, R. E. and Hayes-Roth, B. (1988). OARPLAN: Generating Project Plans by Reasoning about Objects, Actions and Resources. *AI EDAM*. 2(3): 169-181.

David, K. H. C. and Li, G. M. (2001). Modeling Construction Operations with RISim. *Computing in Civil Engineering*. 15(4): 320-328.

Davis, K., Ledbetter, W. B. and Burati, J. L. (1989). Measuring Design and Construction Quality Costs. *Construction Engineering and Management*. 115(3): 385-400.

Deakin, P. (1999). Clients Local Experience on Design and Build Projects. *Proceedings*. *Design and Build Procurement System Semina*r. 11–15 Aug. 124(6): 467–479.

Deming, W. E. (1986). *Out of the Crisis*. Cambridge: Massachusetts Institute of Technology.

Dey, P. K. (2000). Managing Projects in Fast Tracks. *International Public Sector Management*. 13(7): 588-609.

Diaz, C. F. and Hadipriono, F. C. (1993). Nondeterministic Networking Methods. *Construction Engineering and Management*. 119(1): 40-57.

Diekmann, J. E. (1983). Probabilistic Estimating: Mathematics and Applications. *Construction Engineering and Management*. 109(3): 297-308.

Diekmann, J. E., and Girard, M. J. (1995). Are Contract Disputes Predictable? *Construction Engineering and Management*. 121(4): 335–363.

Duchon, J.C. and Smith, T.J. (1993). Extended Workdays and Safety. *International Industrial Ergonomics*. 11: 37-49.

Dulaimi, M. F. and Langford, D. (1999). Job Behavior of Construction Project Managers: Determinants and Assessment. *Construction Engineering and Management*. 125(4): 256-264.

Dumont, P. R., Gibson, G. E. and Fish, J. R. (1997). Scope Management using Project Definition Rating Index. *Management in Engineering*. 13(5): 54–60.

Dunston, P. S. and Bernold, L. E. (2000). Adaptive Control for Safe and Quality Rebar Fabrication. *Construction Engineering and Management*. 126(2): 122-129.

Eldin, N. N. and Egger, S. (1990). Productivity Improvement Tool: Camcorders. *Construction Engineering and Management*. 116(1): 100-111.

Eldin, N. N. (1991). Management of Engineering Design Phase. *Construction Engineering and Management*. 117(1): 163-175.

El-Diraby, T. E. and OConnor, J. T. (2001). Model for Evaluating Bridge Construction Plans. *Construction Engineering and Management*. 127(5): 399-405.

Engineering Statistics Handbook. (2003). *NIST-SEMATECH e-Handbook of Statistical Methods*. http://www.itl.nist.gov/div898/handbook/. December.

Erskine-Murray, P. E. (1972). Construction Planning—Mainly a Question of How. *Occasional Paper No. 2*. London: The Institute of Building.

Etmanczyk, J. S. (1995a). Wisconsin DOT Measures Quality from Top to Bottom. *Management in Engineering*. 11(4): 19-23.

Etmanczyk, J. S. (1995b). *Strategic Planning, Total Quality and Performance Measurement: A Quality Directors Point of View*. Washington. D.C.: National Academy Press. Transportation Resource Record 1498: 65-70.

Everett, J. G. and Slocum, A. H. (1993). CRANIUM: Device for Improving Safety and Productivity. *Construction Engineering and Management*. 119(1): 23-39.

Faniran, O. O., Oluwoye, J. O., and Lenard, D. (1994a). Effective Construction Planning. *Construction Management and Economics*. 12: 485-499.

Faniran, O. O., Oluwoye, J. O., and Lenard, D. (1994b). A Conceptual Process of Construction Planning for Meeting Client Objectives. *Real Estate and Construction*. Singapore. 4(1): 48-57.

Faniran, O. O., Oluwoye, J. O., and Lenard, D. (1998). Interactions between Construction Planning and Influence Factors. *Construction Engineering and Management*. 124(4): 245-256.

Faniran, O. O., Love, P. E. D. and Li, H. (1999). Optimal Allocation of Construction Planning Resources. *Construction Engineering and Management*. 125(5): 311-319.

Fare, R., Grosskopf, S., Lindgren, B. and Roos, P. (1994). *Productivity Developments in Swedish Hospitals: A Malmquist Output Index Approach. Data Envelopment Analysis: Theory, Methodology and Applications.* Stockholm: Kluwer Academic Publishers. 253-272.

Fellows, R. and Liu, A. (1997). *Research Methods for Construction*. MA: Blackwell Science Ltd.

Finke, M. R. (1999). Window Analyses of Compensable Delays. *Construction Engineering and Management*. 125(2): 96-100.

Firdman, H. E. (1991). *Strategic Information Systems: Forging the Business and Technology Alliance*. New York: McGraw-Hill.

Flanagan, R. and Norman, G. (1993). *Risk Management and Construction*. Oxford: Blackwell Scientific.

Fleming, Q. and Koppleman, J. (1994). The Essence of Evolution of Earned Value. *Cost Engineering*. 36(11): 21-27.

Fondahl, J. W. (1960). Photographic Analysis of Construction Operations. *Construction Division*. C02: 86.

Gamerman, D. (1997). *Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference*. Boca Raton, FL: CRC Press.

Gao, Z., Smith, G. R. and Minchin Jr., R. E. (2002). Budget and Schedule Success for Small Capital-Facility Projects. *Management in Engineering*. 18(4): 186-193.

Geary, R. (1962). *Work Study Applied to Building*. UK: Tonbridge Printers Ltd.

Gibson, G. E., Kaczmarowski, J. H. and Lore, H. E. (1993). *Modeling Pre-Project Planning for the Construction of Capital Facilities*. The University of Texas at Austin: Construction Industry Institute. Source Document 94.

Gibson, G. E., and Hamilton, M. R. (1994). *Analysis of Pre-Project Planning Effort and Success Variables for Capital Facility Projects*. University of Texas at Austin: Construction Industry Institute.

Gibson, G. E., Tortora, A. L. and Wilson, C. T. (1994). *Perceptions of Project Representatives Concerning Project Success and Pre-Project Planning Effort*. The University of Texas at Austin: Construction Industry Institute. Source Document 102.

Gibson, G. E. and Dumont, P. R. (1996). *Project Definition Rating Index (PDRI)*. The University of Texas at Austin: Construction Industry Institute. Research Report 113-11.

Gibson, G. E., Liao, S., Broaddus, J. A. and Bruns, T. A. (1997). *The University of Texas System Capital Project Performance, 1990–1995*. Austin: University of Texas System. OFPC Paper. 97-1.

Gieskes, J. F. B. and Broeke, A. M. (2000). Infrastructure under Construction: Continuous Improvement and Learning in Projects. *Integrated Manufacturing Systems*. 11(3): 188-198.

Gilbreth, F.B. (1911). *Motion Study: A Method for Increasing the Efficiency of the Workman*. New York: D. Van Nostrand Company.

Gomar, J. E., Haas, C. T. and Morton, D. P. (2002). Assignment and Allocation Optimization of Partially Multiskilled Workforce. *Construction Engineering and Management*. 128(2): 103–109.

Goodrum, P. M. and Haas, C. T. (2004). Long-Term Impact of Equipment Technology on Labor Productivity in the U.S. Construction Industry at the Activity Level. *Construction Engineering and Management*. 130(1): 124-133.

Gordon, C. M. (1994). Choosing Appropriate Construction Contracting Method. *Construction Engineering and Management*. 120(1): 196-210.

Griffell, T. E. and Lovell, C. A. K. (1996). Deregulation and Productivity Decline: The Case of Spanish Savings Banks. *European Economic Review*. 40(6): 1281-1303.

Griffith, A. F., Gibson, G. E., Hamilton, M. R., Tortora, A. L. and Wilson, C. T. (1999). Project Success Index for Capital Facility Construction Projects. *Performance of Constructed Facilities*. 13(1): 39-45.

Griffith, A. F. and Gibson Jr., G. E. (2001). Alignment during Pre-project Planning. *Management in Engineering*. 17(2): 69-76.

Gunasekaran, A. and Sarhadi, M. (1998). Implementation of Activity-Based Costing and Management. *International Production Economics*. (in press).

Hadipriono, F. C., and Chang, K. S. (1988). Knowledge Base Development for International Construction Operations. *Civil Engineering System*. 5: 220-226.

Hajjar, D. and Abourizk, S. M. (2002). Unified Modeling Methodology for Construction Simulation. *Construction Engineering and Management*. 128(2): 174-185.

Halligan, D. W., Demsetz, L. D. and Brown, J. D. (1994). Action Response Model and Loss of Productivity in Construction. *Construction Engineering and Management*. 120(1): 47-64.

Halpin, D. and Woodhead, R. W. (1980). *Construction Management*. New York: Wiley.

Halpin, D. (1985). *Financial and Cost Concepts for Construction Management*. New York: Wiley.

Halpin, D. W. and Riggs, S. (1992). *Design of Construction and Process Operations*. New York: Wiley.

Hamilton, L. C. (1992). *Regression with Graphics: A Second Course in Applied Statistics*. Belmont California: Wadsworth Inc.

Hamilton, M. R., and Gibson, G. E. (1996). Benchmarking Pre-project Planning Efforts. *Management in Engineering*. 12(2): 25-33.

Han, S. H. and Diekmann, J. E. (2001). Making a Risk-Based Bid Decision for Overseas Construction Projects. *Construction Management and Economics*. 19: 765-776.

Hancher, D.E. and Abd-ElKhalek, H.A. (1998). The Effect of Hot Weather on Construction Labour Productivity and Costs. *Cost Engineering*. 40(4): 32-36.

Hanna, A. S., Russell, J. S., Nordheim, E. V. and Bruggink, M. J. (1999a). Impact of Change Orders on Labor Efficiency for Electrical Construction. *Construction Engineering and Management*. 125(4): 224-232.

Hanna, A. S., Russell, J. S., Gotzion, T. W. and Nordheim, E. V. (1999b). Impact of Change Orders on Labor Efficiency for Mechanical Construction. *Construction Engineering and Management*. 125(3): 176-184.

Hanlon, E. J. and Sanvido, V. E. (1995). Constructability Information Classification Scheme. *Construction Engineering and Management*. 121(4): 337-345.

Hapke, M. and Slowinski, R. (1996). Fuzzy Priority Heuristics for Project Scheduling. *Fuzzy Sets and Systems*. 83: 291-299.

Harris, F. and McCaffer, R. (2001). *Modern Construction Management*. 5th ed. Oxford: Blackwell.

Hayes, S. H. and Wheelwright, A. C. (1984). *Restoring Our Competitive Edge: Competing through Manufacturing*. New York: John Wiley and Sons.

Hegazy, T. and Elbeltagi. E. (1999). Evosite: Evolution-Based Model for Site Layout Planning. *Computing in Civil Engineering*. 13(3): 198-206.

Hegazy, T. and Ersahin, T. (2001). Simplified Spreadsheet Solutions. II: Overall Schedule Optimization. *Construction Engineering and Management*. 127(6): 469-475.

Hemlin, D. (1999). Contractors Local Experience on Design and Build Projects. *Proceedings*. *Design and Build Procurement System*. *Seminar*. 17-25.

Hendrickson, C., Zozoya-Gorostiza, C., Rehak, D., Miller, E. B. and Lim, P. (1987). Expert System for Construction Planning. *Computing in Civil Engineering*. 1(4): 253–269.

Henry, E. and Brothers, H. S. (2001). Cost Analysis between Saber and Design Bid Build Contracting Methods. *Construction Engineering and Management*. 127(5): 359-366.

Herbsman, Z., and Ellis, R. (1991). Research of Factors Influencing Construction Productivity. *Construction Management and Economics*, 8(1): 49-61.

Higgins, B. K., and Dice, C. M. (1984). Quantifying White-Collar Function. *National Productivity Review*. Summer.

Hilsop, R. D. (1991). *A Construction Safety Program*. Professional Safety. Illinois: American Society of Safety Engineers. 15-20.

Hong, T. P., Huang, C. M. and Yu, K. M. (1997). LPT Scheduling for Fuzzy Tasks. *Fuzzy Sets Systems*. 97: 277–286.

Houshyar, A. and Bringelson, L. (1998). A Review of Facilities Planning and Human-Computer Interaction. *International Modeling and Simulation*. 18(2). 14-20.

Hsieh, T.-Y. (1998). Impact of Subcontracting on Site Productivity: Lessons Learned in Taiwan. *Construction Engineering and Management*. 124(2): 91-100.

Hulett, D. T. (1996). *Schedule Risk Analysis Simplified*. Project Management Network. July: 23-30.

IGDS. (2000). *IT Applications and Implementation*. IGDS Workbook Template. Salford: 3-11.

International Labour Office. (1979). *Introduction to Work Study*. 3rd ed. Geneva: ILO.

Ireland, V. (1994). *T40 Process Re-Engineering in Construction*. Australia: Fletcher Construction Limited. Research Report.

Ishii, H. and Tada, M. (1995). Single Machine Scheduling Problem with Fuzzy Precedence Relation. *European Operational Research*. 87: 284-288.

Isidore, L. J., Back, W. E. and Fry, G. T. (2000). Integrated Probabilistic Schedules and Estimates from Project Simulated Data. *Construction Management and Economics*. 19: 417-426.

Jahren, C. T. and Federle, M. O. (1999). Implementation of Quality Improvement for Transportation Construction Administration. *Management in Engineering*. 15(6): 56-65.

Jantzen, J. (1999). *Tutorial On Fuzzy Logic*. University of Denmark: Department of Automation. Report No. 98-E 968(logic).

Jaselskis, E. J. and Ashley, D. B. (1991). Optical Allocation of Project Management Resources for Achieving Success. *Construction Engineering and Management*. 117(2): 321-340.

Jolivet, F. and Batignolles, S. (1986). The Possibility of Anticipating, Several Years in Advance, the Success or Failure of a Project. *Procurement*. Montreal: Project Management Institute. 35-39.

Josephson, P.E. (2000). What We Know and Do Not Know about Poor Quality Costs in Building Projects: Some Experiences. *Implementation of Construction Quality and Related Systems: Proceedings, International Conference*. 281-290.

Josephson, P.-E., and Hammarlund, Y. (1999). The Causes and Costs of Defects In Construction: A Study of Seven Building Projects. *Automation in Construction*. 8(6): 681-687.

Kaming, P. F., Olomolaiye, P.O., Holt, G. D. and Harris, F. C. (1997). Factors Influencing Construction Time and Cost Overruns on High-Rise Projects in Indonesia. *Construction Management and Economics*. 15: 83-94.

Kaming, P. F., Olomolaiye, P.O., Holt, G. D., Harris, F. C. (1998). What Motivates Construction Craftmen in Developing Countries? A Case Study of Indonesia. *Building and Environment*. 33: 131-141.

Kannan, G. and Vorster, M. (2000). Development of an Experience Database for Truck Loading Operations. *Construction Engineering and Management*. 126(3): 201-209.

Karim, A. and Adeli, H. (1999). Object-Oriented Information Model for Construction Project Management. *Construction Engineering and Management*. 125(5): 361-367.

Kartam,S. (1999). Generic Methodology for Analyzing Delay Claims. *Construction Engineering and Management*. 125(6): 409-419.

Kaye, M., and Dyason, M. D. (1999). Achieving a Competitive Focus through Self-Assessment. *Total Quality Management*. 10(3): 373-391.

Keller, G. (1994). *Statistics for Management and Economics*. Belmont California: Wadsworth Publishing.

Kim, Y. (1993). Organizational Assessment for Construction Productivity Improvement. *American Association of Cost Engineers Transactions*. 11-110.

Kim, J.-J., and Ibbs, C. W. (1995). Work-Package - Process Model for Piping Construction. *Construction Engineering and Management*. 121(4): 381-387.

Koo, B. and Fischer, M. (2000). Feasibility Study of 4D-CAD in Commercial Construction. *Construction Engineering and Management*. 126(4): 251-260.

Koskela, L. (1992). *Application of the New Production Philosophy to Construction*. Stanford University: Center for Integrated Facility Engineering. Technical Report No. 72.

Kudla, R. J. (1976). Elements of Effective Corporate Planning. *Long Range Planning*. August: 82–93.

Kuntz, K. A. and Sanvido, V. E., (1995). A Construction Crew Evaluation Model to Improve Productivity. *Contruction Congress*. 201-208.

Kuprenas, J. A., Haraga, R. K., DeChambeau, D. L. and Smith, J. C., (2000). Performance Measurement of Training in Engineering Organizations. *Management in Engineering*. 16(5). 27-33.

Lam, K. C., Lee, D. and Hu, T. (2001). Understanding the Effect of the Learning-Forgetting Phenomenon to Duration of Projects Construction. *International Project Management*. 19: 411-420.

LaPlante, A. (1991). Packages Pinpoint Productivity Problems. *Computerworld*. 25(5): 84-86.

Laufer, A. (1985). On Site Performance Improvement Programs. *Construction Engineering and Management*. 111(1): 82-97.

Laufer, A. and Cohenca, D. (1990). Factors Affecting Construction Planning Outcomes. *Construction Engineering and Management*. 116(1): 135–156.

Laufer, A. and Howell, G. A. (1993). Construction Planning: Revising the Paradigm. *Project Management*. 24(3): 23-33.

Laufer, A., and Tucker, R. L. (1995). Has Construction Project Planning Really Done Its Job? A Critical Examination of Focus, Role and Processes. *Construction Management and Economics*. 5: 243–266.

Layzell, J. P. and Ledbetter, S. R. (1997). Feasibility of Failure Mode and Effects Analysis in the Cladding Industry. *Proceedings of the CIB W-92 Procurement Symposium. Procurement: The Key to Innovation*. 18-22nd May. Montreal. Canada: University of Montreal. 375-385.

Le Bright, R. (1995). Need for Quantum Step Forward in Europe. *Achievement*. December Issue. World Trade Office. Kent. UK. 21.

Ledbetter, W. B. (1994). Quality Performance on Successful Projects. *Construction Engineering and Management*. 120(1): 34-42.

Lee, J. D. (1997). *Validation of a Simulation Model to Evaluate Crew Size*. Santa Monica. CA.

Leu, S. S., Chen, A. T. and Yang, C. H. (1999). Fuzzy Optimal Model for Resource-Constrained Construction Scheduling. *Computing in Civil Engineering*. 13(3): 207-216.

Leu, S. S., Yang, C. H. and Huang, J. C. (2000). Resource Levelling in Construction by Genetic Algorithm-Based Optimization and its Decision Support System Application. *Automation in Construction*. 10: 27-41.

Leung, A. W. T. and Tam, C. M. (1999). Risk Management of BOT Projects in Southeast Asian Countries. *Proceeding: Joint CIB Symposium on Profitable Partnering in Construction Procurement*. London: E & FN Spon. 499-507.

Li, H., and Love, P. E. D. (1998). Combining Rule-Based Expert Systems and Artificial Neural Networks for Mark-Up Estimation. *Construction Management and Economics*. in press.

Li, H., Cao, J. N. and Love, P. E. D. (1999). Using Machine Learning and GA to Solve Time-Cost Trade-Off Problems. *Construction Engineering and Management*. 111(1): 82-97.

Lim, E. C. and Alum, J. (1995). Construction Productivity: Issues Encountered by Contractors in Singapore. *International Project Management*. 13: 51-58.

Liou, F. A. (1984). *A Statistical Study on Work Sampling and Unit Rate Productivity for Power Plants*. University of Texas at Austin: Ph.D. Thesis.

Looney, C. G. (1994). *Fuzzy Reasoning in Information*. *Decision and Control System*. The Netherlands. 511–527.

Lorterapong, P. and Moselhi, O. (1996). Project-Network Analysis using Fuzzy Sets Theory. *Construction Engineering and Management*. 122(4): 308-318.

Lu, M., AbouRizk, S. M. and Hermann, U. H. (2000). Estimating Labor Productivity using Probability Inference Neural Network. *Computing in Civil Engineering*. 14(4): 241-248.

Lu, M., AbouRizk, S. M. and Hermann, U. H. (2001). Sensitivity Analysis of Neural Networks in Spool Fabrication Productivity Studies. *Computing in Civil Engineering*. 15(4): 299-308.

Love, P. E. D. and Gunasekaran, A. (1997). Process Re-Engineering: A Review of Enablers. *International Journal of Production Economics*. 50(2/3): 183-197.

Love, P.E.D., Gunasekaran A. and Li, H. (1998). Concurrent Engineering: A Strategy for Procuring Construction Projects. *International Project Management*. 16(6): 375-383.

Love, P. E. D. and Li, H. (2000). Quantifying the Causes and Costs of Rework In Construction. *Construction Management and Economics*. 18(4): 479-490.

Love, P. E. D. (2002). Influence of Project Type and Procurement Method on Rework Costs in Building Construction Projects. *Construction Engineering and Management*. 128(1): 18-29.

Macomber, J. D. (1989). You Can Manage Construction Risks. *Harvard Business Rev*. 67(2): 155-165.

Mahdjoubi, L. and Yang, J. L. (2001). An Intelligent Materials Routing System on Complex Construction Sites. *Logistics Information Management*. 14(5/6): 337-343.

Mak, S. and Picken, D. (2000). Using Risk Analysis to Determine Construction Project Contingencies. *Construction Engineering and Management*. 126(2): 130-136.

Malmquist, S. (1953). Index Numbers and Indifference Surfaces. *Labour Statistic*. 4: 209-242.

Maloney, W.F. and Mc Fillen, J.M. (1985). Valence of and Satisfaction with Job Outcomes. Proceedings of the American Society of Civil Engineers. *Construction Engineering and Management*. 111(1): 53-73.

Mamdani, E. H., and Assilian, S. (1975). An Experiment in Linguistic Synthesis with a Fuzzy Logic Controller. *International Man-Machine Studies*. 7: 1–13.

Marsh, B. (2002). A Consolidated Approach to Productivity Assessment. *Industrial Technology*. 18(2): 1-8.

Martinez, J. C. and Ioannou P. G. (1999). General-Purpose Systems for Effective Construction Simulation. *Construction Engineering and Management*. 125(4): 265-276.

MATLAB version 6.5.1. Release 13. Copyright 1984-2003. The MathWorks. Inc.

McCabe, D. L. and Narayanan, V. K. (1991). The Life Cycle of the PIMS and BCG Models. *Industrial Marketing Management*. 20: 347-352.

McCoy, F. A. (1986). Measuring Success: Establishing and Maintaining a Baseline. *Procurement*. Project Management Institute. Montreal. 47-52.

McKim, R., Hegazy, T. and Attalla, M. (2000). Project Performance Control in Reconstruction Projects. *Construction Engineering and Management*. 126(2): 137-141.

Microsoft® Excel. (2002). Copyright© Microsoft Corporation. 1985-2001.

Microsoft® Project. (2002). Copyright© Microsoft Corporation. Redmond. WA.

Might, R. J. and Fischer, W. A. (1985). The Role of Structural Factors in Determining Project Management Success. *IEEE Transactions Engineering Management*. 32(2): 71-77.

MIM. (2001). *Management in Malaysia: A Basic Text on General Management with Local Reference to Managing a Malaysian Business*. 2nd Ed. Malaysian Institute of Management: 95-112.

Modern Management Systems. (1983). *Business Roundtables Construction Industry Cost Effectiveness Project*. New York: The Business Roundtable. Report No.A6.

Mohamed, S. (1995). Improving Construction through QFD. *Proceedings of the 1st Pacific Rim Symposium on Quality Deployment*. 15-17th February. Sydney: Macquarie Graduate School of Management. Macquarie University. 238-244.

Mohamed, S. and Tucker, S. (1996). Options for Applying BPR in the Australian Construction Industry. *International Project Management*. 14(6): 379-385.

Mohamed, S. (2002). Thermal Environment and Construction Workers Productivity: Some Evidence from Thailand. *Building and Environment*. Elsevier Science Ltd. In Press.

Mohsini, R. A. and Davidson, C. H. (1992). Determinants of Performance in the Traditional Building Process. *Construction Management and Economics*. 10(4): 343-359.

Mokhtar, A. Bedard, C. and Fazio, P. (2002). Collaborative Planning and Scheduling of Interrelated Design Changes. *Architectural Engineering*. 6(2): 66-75.

Molenaar, K. R., Songer, A. D. and Barash, M. (1999). Public-Sector Design/Build Evolution and Performance. *Management in Engineering*. 15(2): 54-62.

Molenaar, K., Washington, S. and Diekmann, J. (2000). Structural Equation Model of Construction Contract Dispute Potential. *Construction Engineering and Management*. 126(4): 268-277.

Molenaar, K. R. and Songer, A. D. (2001). Web-Based Decision Support Systems: Case Study in Project Delivery. *Computing in Civil Engineering*. 15(4): 259-267.

Monte Carlo (1993). Version 2.0. Primavera Systems. Inc. PA: Bala Cyn-wyd.

Morad, A. A., and Beliveau, Y. J. (1991). Knowledge-Based Planning System. *Construction Engineering and Management*. 117(1): 1-12.

Morehead, A., Steele, M., Alexander, M., Stephen, K. and Duffin, L. (1997). *Changes at Work: The 1995 Workplace Industrial Relations Survey*. Melbourne: Longman.

Morris, P. W. G. (1986). Research at Oxford into the Preconditions of Success and Failure of Major Projects. *Procurement*. Project Management Institute. Montreal. 53-66.

Morris, P. and Hough, G. (1987). *The Anatomy of Major Projects*. New York: John Wiley.

Morrison, P. C. J. (1999). *Cost Structure and the Measurement of Economic Performance: Productivity Utilisation, Cost Economics and Related Performance Indicators*. Kluwer Academic Publishers.

Moselhi, O. (1993). Schedule Compression using the Direct Stiffness Method. *Canadian Journal of Civil Engineering*. 2: 65-72.

Motwani, J., Kumar, A. and Novakoski, M. (1995). Measuring Construction Productivity: A Practical Approach. *Work Study*. 44(8) :18-20.

Mulholland, B. and Christian, J. (1999). Risk Assessment in Construction Schedules. *Construction Engineering and Management*. 125(1): 8-15.

Naoum, S. G. (1994). Critical Analysis of Time and Cost of Management and Traditional Contracts. *Construction Engineering and Management*. 120(4): 687-705.

Nasution, S. H. (1999). Techniques and Applications of Fuzzy Theory to Critical Path Method. *Fuzzy Theory Systems: Technical Applications*. 4: 1562-1697.

Navinchandra, D., Sriram, D. and Logcher, R. D. (1988). GHOST: Project Network Generator. *Computing in Civil Engineering*. 3(2): 239-254.

Neale, R. H., and Neale, D. E. (1989). *Construction Planning*. London: Thomas Telford.

Neil, J.M. and Knack, L.E. (1984). Predicting Productivity. *AACE Transactions of AACE International*. Morgantown. West Virginia.

Nguyen, T. H. and Oloufa, A. A. (2001). Computer-Generated Building Data: Topological Information. *Computing in Civil Engineering*. 15(4): 268-274.

Noor, I. (1998). Measuring Construction Labour Productivity by Daily Visits. *AACE Transactions of AACE International*. Morgantown. West Virginia.

Noyce, D. A. and Hanna, A. S. (1995). *The Impacts of Planned and Unplanned Schedule Compression or Acceleration on the Labor Productivity of Contractors.* WI: The University of Wisconsin-Madison. Technical Report.

Noyce, D. A. and Hanna, A. S. (1998). Planned and Unplanned Schedule Compression: The Impact on Labour. *Construction Management and Economics*. 16: 79-90.

O'Ryan, R., Alarcon, L. F. and Diaz, M. (1997). Environmental Performance Model. *International Environment Conscious Design Manufacturing*. ECDM Press. 2(6): 25-32.

Oakland, J. and Sohal, A. (1996). *Total Quality Management: Text with Cases*. Melbourne: Butterworth Heinemann.

Oberlander, G. D. (1993). *Project Management for Engineering and Construction*. New York: McGraw-Hill.

Obiso, M. L. (1997). *Analysis of Means and Methods of Construction Improvement in Single Family Housing in Mid-Atlantic Rural University Towns*. Virginia Polytechnic Institute and State University: Masters Thesis.

Odeh, A. M. (1992). *CIPROS: Knowledge-Based Construction Integrated Project and Process Planning Simulation System*. University of Michigan. Ann Arbor: Ph.D. Dissertation.

Oglesby, C. H., Parker, H. W. and Howell, G. A. (1989). *Productivity Improvement in Construction*. New York: McGraw-Hill.

Olomolaiye, P. O., Harris, F. C., and Price, A. F. (1996). The Sensitivity of Bricklayers Output to Changes in Skill. *Computers and Structures*. 58: 419-428.

Ottoman, G. R., Nixon, W. B. and Lofgren, S. T. (1999a). Budgeting for Facility Maintenance and Repair. I: Methods and Models. *Management in Engineering*. 15(4): 71-83.

Ottoman, G. R., Nixon, W. B. and Chan, Y. (1999b). Multicriteria Process for Model Selection. *Management in Engineering*. 15(4): 84-95.

Padilla, E. M. and Carr, R. I. (1991). Resource Strategies for Dynamic Project Management. *Construction Engineering and Management*. 117(2): 279-293.

Patton, M. Q. (1986). *Utilization-Focused Evaluation*. 2nd Ed. New York: Sage.

Paulonis, M. A. and Cox, J. W. (2003). A Practical Approach for Large-Scale Controller Performance Assessment, Diagnosis and Improvement. *Process Control*. (13): 155-168.

Peak, J. H. and Lee, Y. W. (1992). Selection of Design-Building Proposal using Fuzzy-Logic System. *Construction Engineering and Management*. 118(2): 303-317.

Pearson, M., and Skues, D. (1999). Control of Projects Implemented through Design and Build Contracts. *Proceedings Design and Build Procurement Systems Seminar*. 49–60.

Perera, S. (1982). Compression of Overlapping Precedence Networks. *The Construction Division*. 108(1): 1-11.

Petroivc, D., Roy, R. and Petroivc, R. (1998). Modeling and Simulation of a Supply Chain in an Uncertain Environment. *European Operation Resources*. 109: 299-309.

Pieper, P. and Allen, S. (1991). Why Construction Industry Productivity is Declining?: Comments. Reply. *Review of Economics and Statistics*. 71(3): 543-549.

Pinto, J. K. and Slevin, D. P. (1988). Critical Success Factors Across the Project Life Cycle. *Project Management*. 19(3): 67-75.

Pinto, J. K., and Slevin, D. P. (1992). *Project Implementation Profile*. New York: Xicom. Tuxedo.

Poister, T. H. (1997). *Performance Measurements in State Departments of Transportation*. Washington. D.C.: National Academy of Sciences Press.

Portas, J. (1996). *Estimating Concrete Formwork Productivity*. Univ. of Alberta: Masters Thesis.

Portas, J. and AbouRizk, S. (1997). Neural Network Model for Estimating Construction Productivity. *Construction Engineering and Management*. 123(4): 399-410.

Pregenzer, L. J., Seppanen, P. J., Kunz, J. C. and Paulson, B. C. (1999). Value-Added Assessment of Construction Plans. *Construction Engineering and Management*. 125(4): 242-248.

Price, A. D. F. (1986). *An Evaluation of Production Output for in Situ Concrete Work*. Loughborough University of Technology: Ph.D. Thesis.

Primavera Project Planner. (2004). Version 3.1. PA: Primavera Systems Inc.

Pritchard, C. L. (2001). *Risk Management: Concepts and Guidance*. VA: ESI International.

Proverbs, D. G., Holt, G. D. and Love, P. E. D. (1999). Logistics of Materials Handling Methods in High Rise In-Situ Construction. *International Physical Distribution and Logistics Management*. 29(10): 659-675.

Que, B. C. (2002). Incorporating Practicability into Genetic Algorithm-Based Time-Cost Optimization. *Construction Engineering and Management.* 128(2): 139-143.

Raftery J. (1994). Risk Analysis in Project Management. London: E & FN Spon.

Ranasinghe, M. (1996). Total Project Cost: A Simplified Model for Decision Makers. *Construction Management and Economics*. 14: 497-505.

Ray, P. and Sahu, S. (1989). The Assessment and Evaluation of White Collar Productivity. *International Journal of Operations and Management*. 9(4): 28-47.

Reed, M. F., Luettich, R. A. and Lamm, L. P. (1993). *Measuring State Transportation Program Performance*. Washington. D.C.: National Cooperative Highway Restoration Program. National Academy Press.

@*RISK* for Project. (1993). Newfield. NY: Palisade. Inc.

Ritchie, E. (1990). Project Compression: A Method Of Speeding Up Resource Constrained Projects Which Preserve The Activity Schedule. *European Operation Resources*. 49(1): 140.

Rogge, D. F. and Tucker, R. L. (1982). Activity Sampling. *Construction Engineering and Management*. 108(4): 592-604.

Rojas, E. M. and Aramvareekul, P. (2003a). Is Construction Labor Productivity Really Declining? *Construction Engineering and Management*. 129(1): 41-46.

Rojas, E. M. and Aramvareekul, P. (2003b). Labor Productivity Drivers and Opportunities in The Construction Industry. *Construction Engineering and Management*. 19(2): 78-82.

Russell, A. D. (1993). Computerized Daily Site Reporting. *Construction Engineering and Management*. 119(2): 385-401.

Russell, A. and Froese, T. (1997). Challenges and a Vision for Computer-Integrated Management Systems for Medium-Sized Contractors. *Canadian Civil Engineering*. 24(2): 180-190.

Saaty, T. L. (1990). *Multi-criteria Decision Making: The Analytic Hierarchy Process*. *AHP Series*. 1. Pittsburgh: RWS.

Sadri, H. (1994). Design of Experiments: An Invaluable Tool for Better Quality and More Productivity. *Production*. 106(2): 40-44.

Samuelsson, P. and Nilsson, L. E. (2002). Self-Assessment Practices in Large Organisations: Experiences from using the EFQM Excellence Model. *International Journal Quality and Reliability Management*. 19(1): 10–23.

Samuelsson, P. and Grans, P. E. (2004). Approach for Assessment and Review in a Large Construction Company: Case of Skanska, Sweden. *Management in Engineering*. 20(1): 2-7.

Santos, A. and Powell, J. A. (2001). Effectiveness of Push and Pull Learning Strategies in Construction Management. *Workplace Learning*. 13(2): 47-56.

Sanvido, V., Grobler, F., Parfitt, K., Guvenis, M. and Coyle, M. (1992). Critical Success Factors for Construction Projects. *Construction Engineering and Management*. 118(1): 94-111.

Sarshar, M., Haigh, R., Finnemore, M., Aouad, G. and Barrett, P. (1999). *Standardised Process Improvement for Construction Enterprises (Spice): Research Methodology and Approach*. COBRA 1999. RICS. Research Foundation.

Sawhney, A., Abudayyeh, O. and Chaitavatputtiporn, T. (1999). Modeling and Analysis of Concrete Production Plant using Petri Nets. *Computing in Civil Engineering*. 13(3): 178-186.

Sayed, T. and Razavi, A. (2000). Comparison of Neural and Conventional Approaches to Mode Choice Analysis. *Computing in Civil Engineering*. 14(1): 23-30.

Schexnayder, C., Weber, S. L. and Brooks, B. T. (1999). Effect of Truck Payload Weight on Production. *Construction Engineering and Management*. 125(1): 1-7.

Schriver, W. and Bowlby, R. (1984) Changes in Productivity and Composition of Output in Building Construction. *Review of Economics and Statistics*. 67: 318-22.

Schuyler, J. R. (2001). *Risk and Decision Analysis in Projects*. PA: Project Management Institute.

Seber, G. A. F. and Lee, A. J. (2003). *Linear Regression Analysis*. 2nd ed. Canada: Wiley.

Senouci, A. B. and Hanna, A. S. (1995). Scheduling of Nonserial Linear Projects with Multiple Non-Overlapping Loop Structures. *Civil Engineering Systems*. 11: 1-17.

Seo, J., Haas, C. T., Saidi, K. and Sreenivasan, S. V. (2000). Graphical Control Interface for Construction and Maintenance Equipment. *Construction Engineering and Management*. 126(3): 210-218.

Shaked, O. and Warszawski, A. (1995). Knowledge-Based System for Construction Planning of High-Rise Buildings. *Construction Engineering and Management*. 121(2): 172-182.

Shapira, S. (1999). Contemporary Trends in Formwork Standards: A Case Study. *Construction Engineering and Management*. 125(2): 69-75.

Shi, J. J. (1999). Activity-Based Construction (ABC) Modeling and Simulation Method. *Construction Engineering and Management*. 125(5): 354-360.

Sinha, S. K. and McKim, R. A. (2000). Artificial Neural Network for Measuring Organizational Effectiveness. *Computing in Civil Engineering*. 14(1): 9-14.

Skolnick, J., Morad, A. and Beliveau, Y. (1990). Development of a CAD-based Construction Visual Schedule Simulation System. *Proceedings of the Project Management Institute*. 334-340.

Smith, G. R. and Hanna, A. S. (1991). Factors Influencing Formwork Productivity. *Proceeding: Annual Conference of CSCE.* Vancouver. Canada. 395-404.

Smith, S. D. (1999). Earthmoving Productivity Estimation using Linear Regression Techniques. *Construction Engineering and Management*. 125(3): 133-141.

Snow, C. and Alexander, M. (1992). Effort: The Illustrative Variable in the Productivity Problem. *Industry Managemen*t. 39(3): 31-32.

Soetrick, F. and Foster, P. (1976). *Research into Time Cost Performance of Building Contracts*. Wellington: Building Research Association of New Zealand. Rep. No. R22.

Son, J. and Skibniewski, M. J. (1999). Multiheuristic Approach for Resource Leveling Problem in Construction Engineering: Hybrid Approach. *Construction Engineering and Management*. 125(1): 23-31.

Songer, A. D. and Molenaar, K. R. (1997). Project Characteristics for Successful Public Sector Design-Build. *Construction Engineering and Management*. 123(1): 34-40.

Sonmez, R. and Rowings, J. E. (1998). Construction Labor Productivity Modeling using Neural Networks. *Construction Engineering and Management*. 124(6): 498-504.

Sozen, Z. and Giritli, H. (1987). Factors Affecting Construction Productivity - A Survey. *International Construction Management & Technology*. 2(1): 49-61.

Spink, P. (1996). Work Motivation: Models for Developing Countries. Reviewing paper by Kanungo. R. N. and Mendonca. M. (1994). *Human Relations*. 49(4): 500-522.

SPSS for Windows. Version 11.0.0. Copyright 1989-2001. SPSS Inc.

Stevens, W. M. (1983). Cost Control: Integrated Cost-Schedule Performance. *Procurement*. New York. 16-27.

Sudit, E. F. (1995). Productivity Measurement in Industrial Operations. *European Journal of Operational Research*. 85(3): 435-454.

Sulaiman, M. J. (1997). *InteSite: An Intelligent Site Layout Planning Within An Object-Oriented Integrated Construction Environment*. University of Salford: Ph.D. Thesis.

Syal, M. G., Grobler, F., Willenbrock, J. H. and Parfitti, M. K. (1992). Construction Project Planning Process Model for Small-Medium Builders. *Construction Engineering and Management*. 118(4): 651-666.

Tah, J. H. M. and Carr, V. (2001). Knowledge-Based Approach to Construction Project Risk Management. *Computing in Civil Engineering*. 15(3): 170-177.

Tam, C. M., Leung, W. T. and Liu, D. K. (2002). Nonlinear Models for Predicting Hoisting Times of Tower Cranes. *Computing in Civil Engineering*. 16(1): 76-81.

Thabet, W. Y. (1992). *A Space-Constrained Resource-Constrained Scheduling System For Multi-Story Buildings*. Virginia Tech: Ph.D. Dissertation.

Thomas, H.R. and Daily, J.M. (1983). Crew Performance Measurement via Activity Sampling. Proceedings of the American Society of Civil Engineers. *Construction Engineering and Management*. 109(3): 263-277.

Thomas, H.R., Guevara, J.M. and Gustenhoven, C.T. (1984). Improving Productivity Estimates by Work Sampling. Proceedings of the American Society of Civil Engineers. *Construction Engineering and Management*. 110(2): 178-188.

Thomas, R. H. and Kramer, D. F. (1988). *The Manual of Construction Productivity Measurement and Performance Evaluation*. Pennsylvania State University: Construction Industry Institute.

Thomas, H. R., Sanvido, V. E. and Sanders, S. R. (1989). Impact of Material Management on Productivity: A Case Study. *Construction Engineering and Management*. 115(3): 370-384.

Thomas, H. R., Maloney, W. F., Smith, G. R., Sanders, S. R., Horner, R. M. W. and Handa, V. K. (1990). Productivity Models for Construction. *Construction Engineering and Management*. 116(4): 705-726.

Thomas, H. R. and Napolitan, C. L. (1995). Quantitative Effects of Construction Changes on Labor Productivity. *Construction Engineering and Management*. 121(3): 290-296.

Thomas, R. H. and Mathews, C. T. (1996). *An Analysis of the Methods for Measuring Construction Productivity*. Pennsylvania State University: Construction Industry Institute.

Thomas, H. R. and Raynar, K.A. (1997). Scheduled Overtime and Labor Productivity Quantitative Analysis. *Construction Engineering and Management*. 123(2): 181-188.

Thomas, H. R., Korte, Q. C., Sanvido, V. E. and Parfitt, M. K. (1999). Conceptual Model for Measuring Productivity of Design and Engineering. *Architectural Engineering*. 5(1): 1-7.

Thomas, H. R. and Zavrski, I. (1999). Construction Baseline Productivity: Theory and Practice. *Construction Engineering and Management*. 125(5): 295-303.

Thomas, H. R. (2000). Schedule Acceleration. Work Flow and Labor Productivity. *Construction Engineering and Management*. 126(4): 261-267.

Thomas, H. R. and Sanvido, V. E. (2000). Role of the Fabricator in Labor Productivity. *Construction Engineering and Management*. 126(5): 358-365.

Thomas, H. R., Horman, M. J., de Souza, U. E. L. and Zavrski, I. (2002). Reducing Variability to Improve Performance as a Lean Construction Principle. *Construction Engineering and Management*. 128(2): 144-154.

Thomas, H. R., Horman, M. J., Minchin, R. E. and Chen, D. (2003). Improving Labor Flow Reliability for Better Productivity as Lean Construction Principle. *Construction Engineering and Management*. 129(3): 251-261.

Thompson, P. A. and Perry, J. G. (1992). *Engineering Construction Risks: A Guide to Project Risk Analysis and Risk Management*. London: Thomas Telford.

Tippett, L.H.C. (1935). *A Snap-Reading Method of Making Time-Studies of Machines and Operatives in Factory Surveys*. The British Textile Institute. 153-170.

Tommelein, I. D. and Ballard, G. (1997). *Coordinating Specialists*. University of California. Construction Engineering and Management Program. Civil and Environment Engineering Department. Technical Report 97-8. Berkeley. CA.

Tommelein, I. D., Riley, D. R. and Howell, G. A. (1999). Parade Game: Impact of Work Flow Variability on Trade Performance. *Construction Engineering and Management*. 125(5): 304-310.

Touran, A. (2003). Probabilistic Model for Cost Contingency. *Construction Engineering and Management*. 129(3): 280-284.

Tucker, R. L. (1990). The Big Q. *Construction Specifier*. May. 151-152.

Venegas, P. and Alarcon, L. F. (1997). Selecting Long-Term Strategies for Construction Firms. *Construction Engineering and Management*. 123(4): 388-398.

Vrat, P. and Kriengkrairut, C. (1986). A Goal Programming Model for Project Crashing with Piecewise Linear Time-Cost Trade-Off. *Engineering Costs and Production Economics*. 10: 161-172.

Waier, P. R. (1998). *Means Unit Price Estimating Methods*. Massachussets: Construction Publishers & Consultants.

Wakisaka, T., Furuya, N., Inoue, Y. and Shiokawa, T. (2000). Automated Construction System for High-Rise Reinforced Concrete Buildings. *Automation in Construction*. 9: 229-250.

Waly, A. F., Thabet, W.Y. and Wakefield, R. (1999). An Automated Model for Generating a Short-Interval Schedule. *Proceedings of 8th DBMC Conference and CIB W78 Workshop*. May 30-June 3. Vancouver. 2386-2392.

Waly, A. F. and Thabet, W. Y. (2002). A Virtual Construction Environment for Preconstruction. *Automation in Construction*. 511: 1-16.

Wang, K-H., Chi, J-H. and Wan, E-H. (1993). Decision Making of Project under Fuzzy Information. *Chinese Institute of Engineers*. 16: 533-541.

Warren, R. H. (1989). *Motivation and Productivity in the Construction Industry*. New York: Van Nostrand Reinhold.

White, C. R. and Austin, J. S. (1989). Productivity Measurement: Untangling the White-Collar Web. *Management in Engineering*. 5(4): 371-378.

Wiggins, J. H. (1988). Construction's Critical Condition. *Civil Engineering*. 58(10): 72-73.

Williams, M. (1996). Graphical Simulation for Project Planning: 4D-Planner. *Proceedings of Computing in Civil Engineering*. 404-409.

Wilson Jr., J. M. and Koehn, E. (2000). Safety Management: Problems Encountered and Recommended Solutions. *Construction Engineering and Management*. 126(1): 77-79.

Winner, R.I. (1988). *The Role of Concurrent Engineering in Weapons System Acquisition*. Institute for Defence Analyses. Report R-338.

Womack, J. P. and Jones, D. T. (1996). *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. New York: Simon and Schuster.

Yang, H., Anumba, C. J., Kamara, J. M. And Carillo, P. (2001). A Fuzzy-Based Analytic Approach to Collaborative Decision Making for Construction Teams. *Logistic Information Management*. 14(5/6): 344-354.

Yates, J. K. (1993). Construction Decision Support System for Delay Analysis. *Construction Engineering and Management*. 119(2): 226-244.

Yu, W. D. and Skibniewski, M. J. (1999). Quantitative Constructability Analysis with a Neuro-Fuzzy Knowledge-Based Multi-Criterion Decision Support System. *Automation in Construction*. 8: 533-565.

Zairi, M. (1996). *Benchmarking for Best Practice: Continuous Learning Through Sustainable Innovation*. Oxford: Butterworth-Heinemann.

Zayed, T. M. and Halpin, D. (2001). Simulation of Concrete Batch Plant Production. *Construction Engineering and Management*. 127(2): 132-141.

Zhang, P., Harris, F. C., Olomolaiye, P. O. and Holt, G. D. (1999). Location Optimization for a Group of Tower Cranes. *Construction Engineering and Management*. 125(2): 115-122.

Zhang, H., Tam, C. M. and Shi, J. J. (2003). Application of Fuzzy Logic to Simulation for Construction Operations. *Computing in Civil Engineering*. 17(1): 38-45.