

**ADOPTING LEAN MANAGEMENT IN NIGERIAN
CONSTRUCTION INDUSTRY**

IBRAHIM HUSSEIN ADEBAYO

A project report submitted in partial fulfillment of the
requirements for the award of the degree of
Master of Science (Construction Management)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

JUNE 2013

I affably dedicate this thesis to my family and my country.

ACKNOWLEDGEMENT

First of all, I would like to express my utmost gratitude to Allah S.W.T for His endless blessings and guidance throughout my entire research process and stay in Malaysia, Alhamdulillah for everything.

Then, sincere appreciation goes to my supervisor Associate Professor, Doctor Mohamad Ibrahim Mohamad for his continued support, guidance, and patience throughout my research. Despite his tight schedule, he always tried to make himself available. I've never seen anyone as committed to nurturing their students like he is. I will always look up to him as an academic role model.

I will forever be grateful to my family, for their undulating support, encouragement and prayers. To them I am truly indebted and words alone cannot describe my earnest gratitude.

I would also like to express my gratitude to my colleagues and friends back in Nigeria for their support when called upon, may Allah reward you all abundantly.

Finally, special thanks to Fuad Abutaha who has been a brother to me here in Malaysia and to all my friends who have always provided aid at various occasions through their views and tips that were undeniably constructive throughout my research and stay in Malaysia. You will all forever remain at heart.

ABSTRACT

Recently the research about waste in construction industry has attracted many researchers around the world. Lean management techniques has is widely accepted as main strategy for waste elimination in work processes. The aim of this study is to propose an efficient and effective methodology to manage construction workflow and minimize waste generation in the Nigeria construction industry based Lean principles. Data were obtained through comprehensive literature review and the used of the questionnaire survey method distributed to clients, consultants, surveyors and contractors in Nigeria construction industry. Also, a case study from the Nigeria highway project was selected and used to create a traditional work process model and an improved lean based work process model. In this study, 35 work process have been identified and evaluated for their contribution to waste. The findings concluded that 22 of them have been identified as contributing to waste at the various stages of construction work. The study also revealed key strategies to improve work process by adopting Lean management techniques supported by other contemporary approach like Concurrent Engineering and Just-In-Time. Adopting the lean based work process model resulted in a shorter project duration and more efficient work proces compared to the traditional. Finally, it is recommended that practitioners should employ lean strategies for the improvement of work process in Nigeria construction industry.

ABSTRAK

Pada masa kini penyelidikan berkaitan dengan proses kerja yang tidak efisien telah menarik minat ramai penyelidik. Kaedah lean sememangnya sudah begitu terkenal sebagai strategi utama dalam mencapai satu sistem pengurusan projek pembinaan yang lebih berkesan. Tujuan kajian ini dijalankan adalah untuk menilai semula proses kerja pembinaan di Nigeria, dari aspek keberkesannya menurut perspektif yang digariskan oleh pengurusan Lean. Kajian ini dijalankan pengumpulan data telah diperolehi melalui kajian literatur yang menyeluruh dan penggunaan borang soal selidik yang diedarkan kepada klien, perunding, juru ukur dan kontraktor di Nigeria industri pembinaan. Selain itu, satu kajian kes dari projek menggunakan projek pembinaan lebuh raya di Nigeria bagi membentuk model proses kerja tradisional dan model proses kerja berasaskan prinsip 'lean' sebagai perbandingan. Dalam kajian ini, 35 proses kerja telah dikenal pasti dan dinilai sebagai penyumbang sebagai proses kerja menurut perspektif lean. Hasil kajian merumuskan bahawa 22 daripada proses kerja tersebut telah dikenal pasti sebagai penyumbang kepada proses yang tidak diperlukan yang dihasilkan di pelbagai peringkat kerja pembinaan. Kajian ini juga menunjukkan penggunaan kaedah Lean yang disokong oleh pendekatan kontemporari lain seperti 'concurrent engineering' dan Just-In-Time mampu memendekkan tempoh pembinaan dan mengurangkan pembaziran proses kerja jika dibandingkan dengan proses kerja tradisional berbanding model proses kerja tradisional. Kajian ini mengesyorkan supaya kaedah pengurusan dengan menggunakan prinsip lean diaplikasikan bagi menambah baik industri pembinaan di Nigeria.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	xi
	LIST OF FIGURES	xii
	LIST OF ABBREVIATIONS	xiv
	LIST OF APPENDICES	xv
1	INTRODUCTION	
	1.1 Introductory Background	1
	1.2 Problem Statement	2
	1.3 Aim and Objectives of the Study	4
	1.4 Scope and Limitations of the Study	5
	1.5 Significance of Study	5
	1.6 Brief Methodology	6
	1.7 Organization of the report	8
2	LEAN MANAGEMENT	
	2.1 Introduction	9
	2.2 History of Lean Production	9
	2.3 Lean Production Management	13
	2.3.1 Definition	13

2.3.2	Lean Production	13
2.3.3	Waste and Value in Lean Production	15
2.3.3.1	Value	15
2.3.3.2	Waste	17
2.3.4	Lean Tools and Techniques	19
2.3.4.1	Just In Time	19
2.3.4.2	Total Quality Control	20
2.3.4.3	Benchmarking	20
2.3.4.4	Concurrent Engineering	21
2.3.4.5	Value Management	22
2.3.4.6	Re-engineering	23
2.3.5	Benefits of Lean Management	23
2.3.6	Application of Lean Management in other Industries	24
2.4	Lean Construction Management	26
2.4.1	Construction as flow production	27
2.5	Lean versus Traditional Construction Management	29
3	NIGERIAN CONSTRUCTION INDUSTRY	
3.1	Introduction	32
3.2	Nigerian Construction	32
3.2.1	Nigerian Construction work Process	35
3.2.2	Waste in Nigerian Construction	36
3.5	Conclusion	42
4	RESEARCH METHODOLOGY	
4.1	Research Design Procedure	43
4.2	Research Design	44
4.3	The Survey Strategy	44
4.4	Survey Data	45
4.4.1	Primary Data	46
4.4.1.1	Questionnaire Survey Structure	46
4.4.2	Secondary Data	47

4.5	Data Analysis Method	48
4.6	Model Development (A highway case study)	49
5	DATA COLLECTION AND ANALYSIS	
5.1	Introduction	50
5.2	Questionnaire Survey	50
5.3	Questionnaire Survey Structure	51
5.3.1	General Information of the Respondents	51
5.3.2	Working Experience of the Respondents	53
5.3.3	Wastage in Current Practice and its Causes	55
5.3.4	Potential Benefits of Applying a New Management Principle	56
5.4	Summary from Survey	58
6	DISCUSSION OF RESULTS	
6.1	Introduction	59
6.2	Need to Improve Current Work Process	59
6.3	Waste Generation in the Current Work Process	60
6.3.1	Design Stage	60
6.3.2	Resource Procurement Stage	61
6.3.3	Material Handling Stage	62
6.3.4	Operational Stage	63
6.4	Strategies to Improve the Current Construction Work Process	64
6.4.1	Design Stage	64
6.4.2	Resource Procurement Stage	65
6.4.3	Material Handling Stage	66
6.4.4	Operational Stage	67
6.5	Lean Work Process versus Traditional Work Process Model	68
6.5.1	Traditional Work Process Model	69
6.5.2	Lean Work Process Model	74
6.5.2.1	Collaborative Planning	77

6.5.2.2	Pull Scheduling	77
6.5.2.3	Just – In – Time Delivery	78
6.5.2.4	Concurrent Engineering	78
6.6	Summary of Results Discussion	78
7	CONCLUSION	
7.1	Introduction	82
7.2	Objective 1: To evaluate waste generated in the current work process in Nigerian construction	82
7.3	Objective 2: To evaluate the potential benefits of applying lean principles to Nigerian construction industry	83
7.4	Objective 3: To develop and compare the benefit of Lean process model compared to traditional process model for Nigeria construction industry	83
7.5	Recommendation for Future Research	84
	REFERENCES	85
	APPENDIX	90

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	Comparison of production systems	14
2.2	The seven types of waste	18
2.3	Comparison between lean and traditional construction	30
3.1	Main Causes of Material Waste	37
3.2	Source and Causes of Time Waste	38
3.3	Waste Variables and Categories	39
3.4	Waste Causes Variables and Categories	40
3.5	Main Causes of Material Waste in Nigerian construction	41
4.1	Research Design	45
4.2	Likert scale scoring	47
4.3	Average Index rating scale	49
5.1	Respondents Grouping	52
5.2	Respondents Organization	53
5.3	Respondents service duration	54
5.4	Factors identified as causing wastage in construction work process	55
5.5	Factors of improving construction work process	57
6.1	Traditional work process	70
6.2	Lean work process	74
6.3	Comparison of lean based and conventional construction work process	81

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1.1	Research Methodology flow chart	7
2.1	Time line marking the critical phases in the lean production evolution	12
2.2	Production flow as a flow process	16
2.3	The seven types of waste	17
2.4	The benefits of Lean	24
2.5	The traditional perception of a production process as a conversion process	28
2.6	Traditional production management work flow	31
2.7	Lean production management work flow	31
5.1	Respondents Grouping	52
5.2	Respondents Organization	53
5.3	Respondents working experience	54
6.1	Factors related to design stage	61
6.2	Factors related to project resource procuring	62
6.3	Factors related to material handling	63
6.4	Factors related to operation	64
6.5	Elements of lean for design stage	65
6.6	Elements of lean for project resource procuring	66
6.7	Elements of lean for material handling	67
6.8	Elements of lean for operation	68
6.9	Traditional work process flow chart (Design and procurement stage)	72
6.10	Traditional work process flow chart (operation stage)	73

6.11	Highest ranking factors related waste generation in construction work process	79
6.12	Highest rank lean strategies	80

LIST OF ABBREVIATIONS

CAGR	Common Annual Growth Rate
GDP	Gross Domestic product
IGLC	International Group of Lean Construction
JIT	Just In Time
LCI	Lean Construction Institution
MRP	Mass Production Concept
NUMMI	New United Motors Manufacturing Incorporation
PWD	Public Works Department
TPS	Toyota Production System
TQC	Total Quality Control
TQM	Total Quality Management

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Questionnaire Template	90

CHAPTER 1

INTRODUCTION

1.1 Introductory Background

The construction industry as seen by different researchers has been tagged as a slow progressing industry associated with many problems such as low productivity, unsatisfactory quality, poor safety, extended project time, which obstructs a customer based oriented project value. Construction projects are diverse in nature as it could either be a stodgy (slow, simple and certain) project on one end or a dynamic (fast, uncertain, and complex) project on the other end (Ballard and Howell, 1998). However, this sector has been experiencing an enormous drawback, which is “Waste”. Various researches have been conducted in the area of construction waste, all recognizing the huge volume of waste generated during a construction project. During the last decades, various methods have been exploited to address the reduction of construction waste and its consequences. One innovative approach suitable in this context is “Lean Construction”, which the construction industry in 1990s was introduced to. Lean construction is based on a successful manufacturing theory, i.e. lean production (Hosseini, et al. 2012).

In manufacturing, lean production philosophy improved competitiveness by the identification and elimination of wasteful activities (non value-adding). However, construction often is viewed and structured as a series of conversion activities only (value-adding). Take for instance, waste activities such as waiting, inventory storage, material movement, and inspection are not normally put into

consideration in Critical Path Models or other construction control tools (Koskela, 1992). Construction has been struggling with integration of the lean management approach into their current project management practice. Traditional and lean management approach have essential differences of the lean “pull” concept compared to the traditional “push” concept (Juanfang and Xing, 2011). But judging from the success of manufacturing, remarkable improvement could be realized by construction simply by identifying and eliminating non conversion activities (non value-adding). In other words, construction should seize to be viewed as just a conversion process but rather should be viewed as flow processes (comprising of waste and conversion activities together) (Koskela, 1992).

This study is based on the evaluation of construction process waste in accordance with the approach of lean thinking. Adopting Lean construction will maximize value and reduce waste by applying specific techniques in a new construction project delivery approach (Ko, 2010). Lean thinking focuses attention on how value is generated rather than how any individual activity is managed. Where current project management view a project as the combination of activities, lean thinking view the entire project in production system terms, that is, as if the project were one large operation (Hosseini, et al., 2012).

1.2 Problem Statement

The notion of quality started way back in time when people attempted to discover an apt quality in every artificial object. Construction industry according to Jimoh, (2012) is regarded as a unique entity which was further described by Wahab and Lawal (2011) as one of the most dynamic and complex industrial development in the world. Jimoh (2012) further emphasized the importance of construction industries as fundamental to the existence of other industries by stating that construction industry provides the environment for the operation of other industries. Nwachukwu and Emoh (2010) ranked construction industry as among the top four of about twenty economic sectors in terms of inter-sector linkages which they

further identified as important to the growth of the economy of a nation by enhancing development through employment provision for a nation.

Construction industry may be responsible for about 20% GDP (Gross domestic product) of a nation and about 12% employment of the total labour force (Wahab and Lawal, 2011). Similarly, Nigerian construction industry plays a major role in the nation's economy, contributing about 61% of the GDP (gross domestic product) of the country and also provides up to 20% of the labour force (Jimoh, 2012, Wahab and Lawal, 2011). Therefore, construction can be considered as one of the major value adding source to the development process of a nation's economy. Nwachukwu and Emoh (2010) further stated that "construction industry is a catalyst, a rock, and the strongest base for rapid economic growth". This is achieved through the job opportunities it creates directly or indirectly to unskilled, semi-skilled and skilled labour. Furthermore, construction also contributes to development of infrastructures such as schools, houses, hospitals, offices, railways, airports, road networks and other relevant infrastructure. However, Nwachukwu and Emoh (2010) emphasized that any constraint to the success of the construction sector will have an overall effect on the growth of economy of a nation.

Unfortunately, Nigeria's construction amongst other developing countries is lagging behind in terms of performance in her construction industry. This can be associated with the adaptation of traditional method of construction which generates various problems such as delay in projects, loss of productivity, cost overrun, abandonment of projects, reworks and sometimes project termination. Traditional construction work process has a lot of wasteful activities associated with it which majorly consumes time and effort without added values to the work (Alwi, et al. 2002a). Wahab and Lawal (2011) highlighted improper control over materials during the various stages of construction process as the source of waste. Alwi et al, (2002b) further stated that design changes, waiting for instructions, poor quality site documentation amongst others as variables of non value added activities which is associated with the traditional method. Garas et al. (2001) in their study pointed out changes in design as a source of waste of time in construction work process, the study also believed that late information is another fundamental cause of material

waste on site. However, it can be recognized that traditional construction method has failed in terms of dealing with problems such as errors and change in design on non value adding activities in construction work process (Sangwon, et al 2007).

The major problem that prompted this study is to find out how wastage in construction work process which commands a significant ratio in terms of time and materials can be best managed to ensure better performance in construction works in Nigeria by adopting a different and effective work process. Various researches have been carried out to identify a lasting solution to reduce construction waste and its effects. One approach which has gained attention and has proven to be effective is “Lean construction theory”. Waste elimination is one of the top main focuses of lean construction theory. However, if Nigeria construction industry continues to adopt the traditional method, not only will this result in waste of time and money, but also hinder the rate of development of the nation considering the impact of construction on the nation’s economy. In order to benefit fully from construction, Nigeria needs to integrate Lean philosophy management approach into her construction sector.

1.3 Aim and Objectives of the Study

The aim of the study is to develop a new lean based work process for construction project in Nigeria to achieve better lean and efficient performance model. This study consists of a set of objectives as follows:

1. To evaluate waste generated in the current construction work process in Nigeria construction
2. To evaluate the potential benefit of applying Lean principles to Nigerian construction industry
3. To develop and compare the benefit of Lean process model compared to traditional process model for Nigeria construction industry.

1.4 Scope and limitations of the Study

The scope of study is focused on reviewing Nigeria construction companies in adopting a lean based work process. Concentration would be on developing a lean process model and identifying the potential benefits when measured up against the current work process. The study limitations are thus stated below:

1. The study is only conducted for Lagos state construction industry in Nigeria, so did with the primary data collection
2. The construction process that will be covered in this study is related to improving site management by reduction or elimination of waste on site during the construction work process.
3. The case study selected for the model in this research was a highway rehabilitation project related to reduction or elimination of waste during the construction work stages

1.5 Significance of Study

The construction industry has a dynamic nature due to the continual increase of uncertainties in technology, budget and development process. Nowadays, projects are getting complex and becoming difficult. However, this sector is of great importance as construction contributes to the economy as stated earlier. Unfortunately, traditional construction is mostly practiced in developing countries like Nigeria, and it is associated with various problems such as non value adding activities “waste” reducing the value of construction.

The importance of this study is considered to be a means to generate value from construction. Lean construction principle is aimed at generating value for both the client and final customer by eliminating factors that do not add value which is considered as “waste”. The project work when completed is expected to recognize the benefits of lean work process over traditional construction work process.

1.6 Brief methodology

The methodology adopted for this study has been presented in a flow chart as shown in figure 1.1 below. This shows the stepwise approach undertaken to achieve the objectives of the study.

The research methodology has been grouped into three (3) stages where the first stage involved thorough review of past journals, articles, conference papers, thesis and books relevant to the study in view.

The second stage is the data collection which is achieved in two (2) ways. Firstly, secondary data was extracted from past journals, articles, conference papers, thesis and books which are then used in the development of questionnaire. Secondly, the primary data was obtained through the use of questionnaire survey to experts in the Nigerian construction industry.

The final stage involved analysis of the obtained data through average index value. This stage also involved the development of the proposed model.

The detailed methodology adopted is thus presented in chapter four (4) of the study.

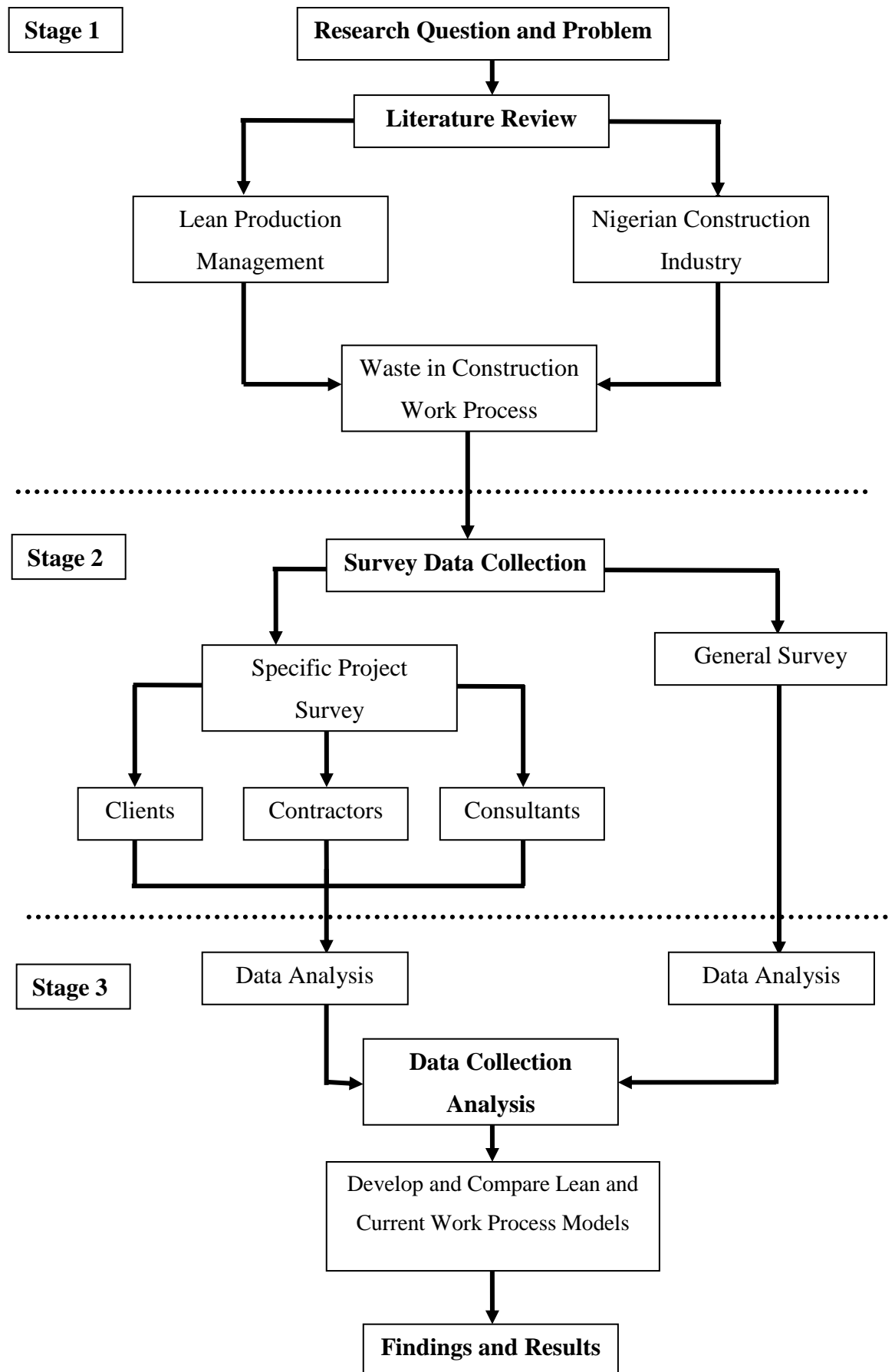


Figure 1.1: Research methodology flow chart

1.7 Organization of report

This thesis is made up of seven chapters, where by the first chapter clearly states the motivation and objectives of this work. The second and third chapters described the relevant literature review, with focus on lean management and Nigerian construction industry. Chapter four introduced the methodology that was used to obtain all the data used for the subsequent chapters. Data obtained and analysis was presented in chapter five with clear representation of data breakdown and detailed bio data on the respondents. Detailed discussion of results was presented in chapter six. Also, the proposed models were generated using work breakdown structure of the construction work process in this chapter. Both models were later compared to identify the potential of the improved lean work process model. The final chapter of this work concluded it all and also presented recommendations for further study.

REFERENCES

- Alwi, S., Hampson, K. D., & Mohamed, S. A. (2002a). Non value-adding activities: A comparative study of Indonesian and Australian construction projects. *In Proceedings: International Conference on Advancement in Design, Construction, Construction Management and Maintenance of Building Structure, Bali.*, 270-278.
- Alwi, S., Hampson, K. D., & Mohamed, S. A. (2002b). Waste in the Indonesian construction projects. *In Proceedings: The 1st International Conference of CIB W107 - Creating a sustainable Construction Industry in Developing Countries, South Africa.* , 305-315
- Anumba, C. J., & Evbuomwan, N. F. O. (1997). Concurrent engineering in design-build projects. *Construction Management & Economics*, 15(3), 271-281.
- Ballard, G., & Howell, G. (1994). Implementing lean construction: stabilizing work flow. *Lean construction*, 101-110.
- Ballard, G., & Howell, G. (1998). What kind of production is construction. *Paper presented at the 6th International Conference on Lean Construction, Guarujá, Brazil.*
- Burns, N., & Grove, S.K. (1987). "The practice of research, conduct, critique, and utilization". *Philadelphia: Saunders.* 1987.
- Crowley, A. (1998). Construction as a manufacturing process: Lessons from the automotive industry. *Computers & Structures*, 67(5), 389-400.
- Crute, V., Ward, Y., Brown, S., & Graves, A. (2003). Implementing Lean in aerospace—challenging the assumptions and understanding the challenges.. *Technovation*, 23(12), 917-928.
- Garas, G. L., Anis, A. R., & El Gammal, A. (2001). Materials waste in the Egyptian construction industry. *Proceedings IGLC-9, Singapore.*

- Hosseini, S. A. A., Nikakhtar, A., Wong, K. Y., & Zavichi, A. (2012). Implementing lean construction theory into construction processes' waste management. *Paper presented at the International Conference on Sustainable Design and Construction 2011: Integrating Sustainability Practices in the Construction Industry*, ICSDC 2011, March 23, 2011 - March 25, 2011, Kansas City, MO, United states.
- Howell, G., & Ballard, G. (1998). Implementing lean construction: understanding and action. *Paper presented at the Proc. 6 th Ann. Conf. Intl. Group for Lean Constr.*
- Howell, G. A. (1999). What is lean construction-1999. *Paper presented at the Proceedings IGLC.*
- Jimoh, R. (2012). Improving Site Management Practices in the Nigerian Construction Industry: The Builders' Perspective. *Ethiopian Journal of Environmental Studies and Management*, 5(4), 366-372.
- Juanfang, L., & Xing, L. (2011). Application of lean construction in quality management of engineering projects. *Paper presented at the 2nd International Conference on E-Business and E-Government*, ICEE 2011, May 6, 2011 - May 8, 2011, Shanghai, China.
- Kennedy, F. A., & Widener, S. K. (2008). A control framework: Insights from evidence on lean accounting. *Management Accounting Research*, 19(4), 301-323.
- Kim, D. (2002). Exploratory study of lean construction: Assessment of lean implementation. *Unpublished 3108494, The University of Texas at Austin, United States -- Texas.*
- Ko, C. H. (2010). Application of lean production system in the construction industry: An empirical study. *Journal of Engineering and Applied Sciences*, 5(2), 71-77.
- Koskela, L. (1992). Application of the new production philosophy to construction: *Stanford university (Technical Report No. 72, Center for Integrated Facility Engineering, Department of Civil Engineering)*. Stanford, CA. (Vol. 72)
- Kpamma, E. Z., & Adjei-Kumi, T. (2011). Management of Waste in the Building Design Process: The Ghanaian Consultants' Perspective. *Architectural Engineering and Design Management*, 7(2), 102-112.

- Lajevardi, A., Endut, I. R., & Paydar, S. (2011). Application of lean model to reduce waste of time in construction case study of concreting task in Malaysia. *Paper presented at the 2011 IEEE Colloquium on Humanities, Science and Engineering, CHUSER 2011, December 5, 2011 - December 6, 2011, Penang, Malaysia.*
- Lobiondo-Wood, G., & Haber, J. (1998). "Nursing research: Methods, critical appraisal, and utilization" (4th ed.). *St. Louis, MO: Mosby.* 1998 Melton, T. (2005). The Benefits of Lean Manufacturing: What Lean Thinking has to Offer the Process Industries. *Chemical Engineering Research and Design*, 83(6), 662-673.
- Mbamali, I. & Okotie, A.J. (2012). "An Assessment of the Threats and Opportunities of Globalization on Building Practice in Nigeria" *American International Journal of Contemporary Research*, 2 (4) pp143-150
- McCuen R.H ed. (1996). "The Elements of Academic Research", *ASCE press, New York.* 1996.
- Melton, T. (2005). The Benefits of Lean Manufacturing: What Lean Thinking has to Offer the Process Industries. *Chemical Engineering Research and Design*, 83(6), 662-673.
- Nahmens, I., & Mullens, M. A. (2011). Lean homebuilding: Lessons learned from a precast concrete panelizer. *Journal of Architectural Engineering*, 17(4), 155-161.
- Nwachukwu, C. C., & Emoh, F. I. (2010). A Systems Approach in Analysing Material Constraining Factors to Construction Project Management Success in Nigeria. *Interdisciplinary Journal of Contemporary Research in Business (IJCRB)*, 2(7), 37.
- Oke, A. E., & Ogunsemi, D. R. (2009). Value Management in the Nigerian Construction Industry: Militating Factors and the Perceived Benefits.
- Oladiran, O. J. (2009). Causes And Minimization Techniques Of Materials Waste In Nigerian Construction Process. *Paper presented at the Fifth International Conference on Construction in the 21st Century (CITC-V) "Collaboration and Integration in Engineering, Management and Technology" Istanbul, Turkey.*

- Oladiran, O. J. (2009b). Innovative Waste Management Through the Use of Waste Management Plans on Construction Projects in Nigeria. *Architectural Engineering and Design Management*, 5(3), 165-176.
- Petersen, K., & Wohlin, C. (2010). Software process improvement through the Lean Measurement (SPI-LEAM) method. *Journal of Systems and Software*, 83(7), 1275-1287.
- Polat, G., & Ballard, G. (2004). Waste in Turkish construction: need for lean construction techniques. *Paper presented at the Proceedings*.
- Qiu, X. (2011). Uncertainty in project management based on lean construction implementation. *Paper presented at the 2011 International Conference on Mechatronics and Materials Processing, ICMMP 2011*, November 18, 2011 - November 20, 2011, Guangzhou, China.
- Radnor, Z. J., Holweg, M., & Waring, J. (2012). Lean in healthcare: The unfilled promise?. *Social Science & Medicine*, 74(3), 364-371.
- Rivera, L., & Frank Chen, F. (2007). Measuring the impact of Lean tools on the cost-time investment of a product using cost-time profiles. *Robotics and Computer-Integrated Manufacturing*, 23(6), 684-689.
- Salvatierra-Garrido, J., & Pasquire, C. (2011). Value theory in lean construction. *Journal of Financial Management of Property and Construction*, 16(1), 8-18.
- Sangwon, H., SangHyun, L., Fard, M. G., & Pena-Mora, F. (2007, 9-12 Dec. 2007). Modeling and representation of non-value adding activities due to errors and changes in design and construction projects. *Paper presented at the Simulation Conference, 2007 Winter*.
- Shah, R., & Ward, P. T. (2007). Defining and developing measures of lean production. *Journal of Operations Management*, 25(4), 785-805.
- Teddle, C., & Yu, F. (2007). Mixed Methods Sampling A Typology With Examples. *Journal of mixed methods research*, 1(1), 77-100
- Tosin Oluwakiyesi (2011). "Construction Industry Report: A Haven of Opportunities" *Vetiva Capital Management Limited*
- Wahab, A., & Lawal, A. (2011). An evaluation of waste control measures in construction industry in Nigeria. *African Journal of Environmental Science and Technology*, 5(3), 246-254.

Wodalski M. J., Thompson B. P., Gary Whited, Hanna A. S. (2011). Applying Lean Techniques in the Delivery of Transportation Infrastructure Construction Projects. *National Center for Freight & Infrastructure Research & Education CFIRE 03*

Womack, J. P., Jones, D. T., & Roos, D. (1990). *The Machine That Changed the World: The Story of Lean Production: How Japan's Secret Weapon in the Global Auto Wars Will Revolutionize Western Industry.* New York, NY: Rawson Associates.