EXPLORATION OF IMPLEMENTATION OF THE LAST PLANNER SYSTEM OF PRODUCTION CONTROL BY CHINESE CONTRACTORS: A CASE STUDY

A Thesis

by

HUAZHANG HUANG

Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Chair of Committee,	Zofia K. Rybkowski
Committee Members,	José L. Fernández-Solís
	Rodney C. Hill
Head of Department,	Joseph P. Horlen

December 2015

Major Subject: Construction Management

ABSTRACT

During the past two decades, Lean Construction has been utilized in over 200 pilot projects in different countries all over the world except for China. Although qualitative inquiries have been made regarding the applicability of the Last Planner System of Production Control (hereafter referred to as LPS) in China, on site exploration effort of LPS implementation in China is still lacking, and subsequently the clear strategies for implementation on site. The thesis presented the first on site exploration of LPS in China to the scholars and researchers from the lean community worldwide. The main method used in this thesis is case study and literature review. Case study was used to expose the challenges for implementing LPS in China while the literature review was used to find solutions for one challenge revealed in the case study. Major findings of this study include: (1) the main constraints of LPS in China are exclusion of foremen during the planning process, no update on planning information, and lack of cooperation among different parties; (2) the power distance inside the general contractor is relatively easy to solve comparing to the power distance between general contractors and subcontractors; (3) the team leader of the trade foremen can serve as the last planner in China. Findings from a literature review suggest that power distance can be reduced if top management authorizes changes to encourage and reward subordinates to express their opinions. This thesis recommends further research on the adaption of LPS in China. Future work on more pilot projects in China is needed to initiate the use of LPS by Chinese contractors, and then further increase the use of LPS worldwide.

DEDICATION

To my dear parents and friends for all the faith they put in me.

ACKNOWLEDGEMENTS

First I would like to thank Dr. Rybkowski for her incredible support and guidance throughout my entire graduate study in Texas A&M University. Her dedication to research and personal attention to students deserves the greatest admiration. Thanks to her resourceful academic and professional career, Dr. Rybkowski not only provided valuable advice when I needed them, but also enlightened me during our conversations when I got into hard times. I would also like to thank Dr. Solis for his encouragement and support. I'm also grateful to Dr. Hill and Dr. Shepley for being my committee members and providing valuable advice.

Additionally, I would like to give my appreciation to Dr. Kang, who provided me with an amazing opportunity to participate in the interdisciplinary project to improve my professional skills. Thanks to Dr. Bigelow, I have confidence in doing excellent estimation in the real project.

Moreover, I would like to thank Yong Li and the Chinese Railway Construction Corporation for generously providing me with unlimited access to the site and project records.

Finally, I would like to express my gratitude to my parents for their unconditional love and support. As for my auntie, she set a role model for me to surpass. Last but not the least, I would like to give my special appreciation for my friends Anny Wang, Collin Zuo and Yuexin Sun, plus my distant friends all over the world. Owing to their continuous support and understanding through good and bad times, I am able to be the person I aspired to be.

NOMENCLATURE

LPS	Last Planner System
IGLC	International Group of Lean Construction
LCI	Lean Construction Institute
PPC	Percent Plan Complete
TFV	Transformation-Flow-Value
WWP	Weekly Work Plan
TPC	Traditional Production Control
LC	Lean Construction

TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

LIST OF TABLES

Page

CHAPTER I

INTRODUCTION

Low productivity has always been an issue for the Chinese construction industry. Many factors have contributed to this situation. An inadequate construction management system is one of the most important causes. Since the beginning of the 21th century, the Design-Bid-Build approach has always served as the dominant project delivery system in China (Chen et al. 2011). The prevalence of the Design-Bid-Build approach in China separates the design institutes, subcontractors and general contractors, which encourages each party to only be held responsible for its own work. Owing to the low productivity and the systematic nature of Chinese construction industry, Chinese construction companies have yet to attain international competitiveness; this makes the exploration of lean methods necessary.

The successes of lean principles in manufacturing, and the benefits arising from its use have led to the development of lean implementation in construction (Egan 1998). A major contribution to the implementation of lean in construction was the creation of the Last Planner System by Ballard (2000) and his colleagues. Last planner, as indicated by its name, refers to the last individual in a workflow process, turning what traditionally should be done to what will be done. Implementing the LPS will not only enhance collaboration, but also foster a creative environment for subcontractors and vendors to exchange information.

Over the years, LPS has been implemented on construction projects worldwide, including the US, the UK, Korea, etc. The benefits, motivations and implementation challenges of LPS are well documented (Fernandez-Solis et al. 2012). In addition to the efforts made by developed countries, developing countries also made contributions towards the implementation. Cerveró-Romero et al. (2013) has addressed issues such as barriers, difficulties and benefits of seven pilot projects in Mexico, which used the Last Planner System. Barbosa et al. (2013) placed emphasis on the development of implementation plan. However, although the efficiency of Last Planner System has been tested in cases around the world and in academia (Seppänen et al. 2010), the Last Planner System still needs to be tailored according to a country's culture and the company that runs it (Cerveró-Romero et al. 2013).

Optimization of workflow and predictable work downstream might be what the Chinese construction industry needs. After initiating the Reform and Open Policy, the construction industry has gradually become a pillar of the Chinese economy, sharing connections with almost all other industries at a macroeconomic level. The value of construction put in place grew from 922 billion US dollars in the 3rd quarter of 2010 to 2,549 billion US dollars in the 3rd quarter of 2014, increasing by 176% (National Bureau of Statistics of China 2014). Also, activity in the construction industry positively correlates with the development cycle of the national economy. That is to say, the scale of the construction industry depends largely on the demand of the national economy on fixed assets, especially with regard to infrastructure, real estate, and the evolution of urbanization.

However, the transferability of lean construction methods such as the Last Planner System to China still needs exploration, which both Lean Construction Institute (LCI) and International Group for Lean Construction (IGLC) have not addressed. Fernández-Solís (2008) stated that the difference between the procedure-dominated construction process and the product-oriented manufacturing process has led to the rethinking of existing paradigms. Under such circumstances, in order to create enough momentum for wide adoption of Last Planner System, recording implementation efforts in the case studies is not enough to convince the contractors to adopt the Last Planner System. Questionnaire surveys have been handed out to the industry professionals in China to collect their response on the prospect of implementation of LPS (Gao and Low 2014). Although the questionnaire surveys offers the benefit of reaching out to more people, the respondents are restricted by the choices set by the researcher, resulting in inability to reflect their true opinions (Naoum 2012).

The author of this thesis argued that to essentially initiate the overall change of the lean process, lean methods, including the Last Planner System, must be tailored according to the cultural differences and systematic nature of the country. The process of adaption to the local culture and systematic nature should be investigated through case studies to inspire confidence in construction professionals to initiate larger adoption. Exploring the modification of the Last Planner System on a Chinese construction site will speed up the process of applying lean methods in China.

The intent of this research is to identify the constraints preventing the adoption of the Last Planner System by Chinese contractors, using an in-depth case study. The study

will propose possible solutions in helping the implementation of LPS on site in China. This research is significant because it allows Chinese construction firms to go one step closer to tapping into the benefits of the LPS. For the time being, the on-site study of implementing the LPS in China has yet to be explored. This study will also contribute to filling the gap of studying the feasibility of implementing the lean construction method on site in China.

CHAPTER II

LITERATURE REVIEW

2.1 Origins of Last Planner System

Lean Construction is a relatively new construction project management tool utilizing concepts from manufacturing to achieve better workflow control. Lean views LPS and Transformation-Flow-Value model of production as two branches of research in the field. According to Ballard (2000), the primary target of the LPS is to uphold the elimination of non-value adding activities (waste), and guide workflow across the project teams in an appropriate amount and pace. Eliminating waste and guiding workflow is a joint effort requiring the cooperation of upper level management with all site staff to ensure that there are no workers waiting for work and that no work is waiting for workers. However, sometimes the application of a Production Control System is mixed with the continued use of traditional management methods. The integration of the two systems could result in insufficient control given that a project control model relies on the Traditional Production Control (TPC) System (Koskela and Ballard 2006). LPS was designed to address this problem (Ballard and Howell 1998). According to a previous study, the use of LPS positively affects the safety, productivity and cost of construction operations (Leal and ALARCÓN 2010).

Alternatively, Koskela (1999) proposed to understand construction as a type of production. In fact, lean construction methods have been described as a "new production philosophy" (Koskela 1992). Koskela (1999) provided three different ways to understand the production process: conversion view, flow view and value generation

view, which lay the foundation for future development of lean construction. However, traditional construction was still considered only as a series of conversion activities (Koskela 1992). The conversion model had ruled the construction industry until very recently (Huovila and Koskela 1998), causing the slow adoption of lean methods. According to a survey conducted by McGraw Hill Construction, 28% of the construction companies in the U.S. have implemented at least one practice, 35% are familiar with Lean Construction (LC), but have not implemented any practices, and 37% of contractors are not familiar with LC (McGraw-Hill Report 2013).

2.2 Goal of Last Planner System

The goal of LC is to continuously improve the work process by reducing waste in each step during the construction, thus adding value to the end users (Pasquire and Connolly 2002; Rybkowski et al. 2013). There are many techniques already developed such as "Just-In-Time" (JIT) and "Jidoka" to achieve this goal.

Among them, LPS is the most advanced and widely used technique in the construction industry with positive impacts on project performance (McGraw-Hill Report 2013). It is designed to reduce unpredictability in the production process. LPS also creates a flow in the production process to generate more value for stakeholders and customers (Ballard and Howell 2003; Salem et al. 2006; Thomas et al. 2004). Its fundamental principle is to warrant that all the prerequisites needed to perform distinct construction work are in place before a workgroup receives the assignments (Ala-Risku and Kärkkäinen 2006).

2.3 Components of Last Planner System

To do that, the system consists of a four-level hierarchy of schedules and planning tools. They are the master plan, the phase (pull) plan, the look-ahead plan, and the weekly work plan (WWP) (Kenley and Seppänen 2006). The master schedule is the general project plan, which is guided by the project objective and design criteria set by clients. It contains only the major milestones. The dates of milestones are settled starting with the planned phase completion dates and working backward to the beginning (Nieto-Morote and Ruz-Vila 2011). Next, the look-ahead schedule is the subsequent level of planning. It is a preparation for the potential work, which usually takes 6 to 8 weeks depending on the project characteristics, the reliability of the planning system and the lead times. In order to meet the master schedule, constraint analysis is conducted to screen the activities that can be done. All of the constraints are identified to come up with a workable backlog. The short-term schedule is a one-week schedule on a detailed assignment basis. Every single assignment or activity is derived from the ones that are complying with the completion dates in the look-ahead schedule. Work assignments must be ready to begin before entering the WWP. That is to say, all constraints must have been eliminated, all previous work must have been done, and resources must be ready and correctly assigned to complete the task (Choo et al. 1999). A Person or group conducting those assignments is called the "Last Planner" (Ballard 1994).

The WWP relies on Percent Plan Complete to record the percentage of completed work and constraint analysis to find out the reasons why planned work was not completed for reflecting on any variations to the plan. It is calculated by dividing the

number of assignments that were accomplished in one week by the total number of tasks in the WWP. For those tasks that have been planned but not completed, a constraint analysis is conducted to find the root causes to prevent them from happening again. The higher the PPC, the more predictability the project has.

2.4 Implementation Effort

Ever since Ballard and Howell (1998) initiated the development of the Last Planner System of Production Control, this new operating system has been implemented in numerous projects worldwide (AlSehaimi et al. 2009; Barbosa et al. 2013; Cerveró-Romero et al. 2013; Daniel et al. 2013; Hamzeh and Aridi 2013; Liu and Ballard 2009). The numbers of concepts, tools and metrics applied in LPS have also experienced a rapid increase. Researchers can find a majority of case studies through the International Group for Lean Construction (IGLC) and Lean Construction Institute (LCI). According to Fernandez-Solis et al. (2012), researchers from the IGLC and LCI have collected data from over 200 projects since 1996.

Recent efforts include applying LPS to a chemical plant construction (Nieto-Morote and Ruz-Vila 2011). A problem concerning information flow was found among the team members, in which the supervisor lacked knowledge about the incoming work unless the project had been perfectly designed. This problem caused long delays in the project. The implementation of LPS resulted in both a lower percentage and quality of completed activities. AlSehaimi et al. (2009) presented the primary results of implementing LPS on two construction projects in Saudi Arabia. The results indicated the benefits gained in terms of improving project planning and site management. In one

of the sites, the structural work finished two weeks ahead of the schedule. However, the results also revealed some potential barriers such as lengthy approval procedure and shot term vision, encumbering the full capability of the LPS.

2.5 The Status of Chinese Construction Industry

2.5.1 Introduction

Since the "Reform and Opening" policy in the 1980s, China has been experiencing a booming speed of economic growth comparing to other countries. The construction industry has also grown exponentially over the same period of time. According to the National Bureau of Statistics of China, the number of construction enterprises increased from 6604 in 1980 to 79528 in 2013. The gross output value accumulated from 28.69 billion yuan (4.63 billion US dollars) to 15931.30 billion yuan (2570.35 billion US dollars). By the end of 2013, there are 45 million registered employees in the Chinese construction industry, which contributed 6.9% of the Gross Domestic Product. These figures clearly show that during the process of economic prosperity, the construction industry that leads infrastructure and urban development played a leading role as an individual industry. However, the performance over the recent years and intrinsic systematic nature has placed Chinese general contractors in a difficult position.

2.5.2 Quality

Despite the reputation Chinese construction companies made by finishing project like Three Gorges Dam and Bird's Nest Stadium, the average quality level of Chinese construction companies remains to be questioned. Sacrificing quality in exchange for time and money was one of the most critical problems in the 1990s when the construction industry was almost entirely policy oriented (Chan et al. 2007), and it is still a large-scale problem. Lacking adequate supervision systems, Chinese contractors hire supervision firms to fulfill the responsibility of overseeing the project. However, supervision firms' overly-close relationships with contractors made it less likely to enhance rigorous supervision, allowing possible corruption (Le et al. 2014). On the contractors' side, Zeng et al. (2005) pointed out that the Chinese government has been trying to implement Total Quality Management framework and ISO 9000 certification. However, as Liu et al. (2014) pointed out that considering the development of Chinese construction industry depends heavily on geographic location; the implementation of the quality assurance system is low for typical Chinese contractors.

2.5.3 Project Management

As Chinese contractors seldom implement an international standard of quality, the responsibility of planning relies on the project manager's rich experience and ability to solve the problem on site. As Gao and Low (2014) pointed out, PM's planning skills combined with the subcontractor's willingness to follow allow for better reliability of the planning if such strength can be properly utilized, which is an advantage of the Last Planner System implementation in China. However, according to Chen and Partington

(2004), cautions have to be taken before introducing western project management process into China, considering the cross-cultural difference of management process. The figure II-1 below listed several cultural differences between the Chinese contractors and US contractors.

Important dimensional differences between Chinese and Western cultures [6–8,11–13]

Chinese culture	Western culture (UK & USA)
Collectivism	Individualism
Large power distance	Small power distance
Strong uncertainty avoidance	Weak uncertainty avoidance
Long-term orientation	Short-term orientation
Outer-directed	Inner-directed
Relationship	Contractual
Conservatism, tension between hierarchy and harmony	Autonomy, tension between mastery and egalitarian commitment/ harmony

Figure II-1 Dimensional differences between Chinese and Western Culture (Reprinted from Chen and Partington 2004)

Although benefits of LPS, such as plan reliability, safety, and quality have been recorded, only a few the articles mentioned that the function of cross-cultural difference has an impact on the process of transferring LPS to different countries (AlSehaimi et al. 2009; Barbosa et al. 2013; Daniel et al. 2013; Pavez and Alarcón 2008).

2.6 The Need for Change

The Chinese construction industry is a policy-oriented field, which fluctuates regularly according to the government policy. Since the beginning of the 21th century, Chinese contractors have shifted from fulfilling state target as a priority to profit maximization. According to the National Bureau of Statistics of China, the growth rate

of the construction industry in recent years has dropped dramatically. China has now calmed down from the fanaticism for purchasing houses a few years ago. The Chinese government intermittently updates house purchase bans, especially in second and third tier cities, reflecting its determination to avert a speculative real estate bubble.

As the real estate market has diminished, all the stakeholders in the construction market have been affected. Without loose loan conditions provided by banks, middle size general contractors and some owners have found it harder to get projects back on track. As a result, those contractors have no choice but to lay off employees in order to survive in the market. Owing to the lack of a proper project management system and poor quality control, many Chinese contractors will have a hard time remaining competitive. However, a number of companies in the U.S. have already embarked on a lean optimization process to stay competitive, according to their websites and the project portfolio. For example, Turner Construction Company implements a lean approach to define deliverables as clearly as possible in order to eliminate the waste of waiting and reworking.

Although the Chinese economy, along with the construction industry, achieved substantial gains over the past 30 years, the growth rate of the economy has recently dropped from double digits to a single digit. Since the Chinese construction industry is affected by the government policy at a macroeconomic level, the housing demand has decreased, leaving fewer projects for Chinese contractors. As a more thorough regulation system is being developed, a more positive industry climate will be formed in the Chinese construction market. Only those companies that are equipped with advanced

technology and project management systems can balance the time, cost and quality well to be leaders in this industry. The evidence mentioned has shown that the Last Planner System is relevant for solving the problems of Chinese contractors and enhancing their competiveness. However, a practical implementation of lean in the construction industry is next to zero in China. Chinese scholars are detached from industry professionals; therefore they rarely have a chance to explore the possibility of lean construction in China. International scholars are restricted by the cultural barriers and hardly have access to collect data from Chinese contractor

2.7 The Need for Study

Through the endeavor of the researchers discussed in the literature review, LPS has proven its value and is already considered an industry standard practice of LC. Considering the size of the Chinese construction industry, even applying LPS to a small extent may bring tremendous upgrades in terms of project performance. In addition, as the fervor of the real estate market has cooled down, Chinese contractors will have more difficulty in keeping the cost and time down in order to maintain the same revenue. LPS will enhance the competitiveness of large Chinese construction companies to conquer more complex projects internationally and help the middle size contractors to survive in the market. Although the benefits of the LPS have been well documented, practitioners in Sweden still regard it as a theory. In a developing country like China, LPS is rarely known among the construction professionals. According to Seddon et al. (2011), lean is lightly adopted in many commercial industries outside the car manufacturing.

Decent efforts on exploring the prospect of LPS in the Chinese construction industry are still lacking. Gao and Low (2014) presented a report on the perception of Chinese building professionals on the application of LPS in Chinese construction projects. The report provided qualitative inquiries about the relevance of LPS in the Chinese construction industry. However, an in-depth case study, which demonstrates the rationality of applying Last Planner System, is still lacking. If there is little description of how to implement LPS on site in detail other than some vague description, general contractors in China will have little interest in adopting LPS on sites. Additionally, it is critical that academics not only describe the world, but also make attempts to improve the world (Koskela 2011).

CHAPTER III

RESEARCH METHODS

The primary goals of this research are to examine the relevance of LPS at a project management level in China and assess the challenges might encountered during the implementation of LPS in China. The final goal is to provide strategies on the implementation of the LPS in China. The concentration of this research is to fill the gap of assessing the challenges while implementing the LPS at a project level in China based on the results of an in-depth case study instead of using qualitative survey.

The research is divided into two phases. The first phase is the in-depth case study phase. In this phase, the researcher collects data from a construction site in southwestern China: productivity of labor, waste incurred during construction and constraints that impede efficiency. The data comes from observations on site and construction documents. The researcher has spent three months on a construction site in order to interact with the staff thus providing a fresh view on the LPS implementation. Additionally, the researcher has also written down details about the problems encountered during site visits.

During the second phase, the researcher has conducted a literature review about one challenge found in the first phase in order to find solutions from the previous research in other fields. Figure III-1 demonstrates the research design of this study.

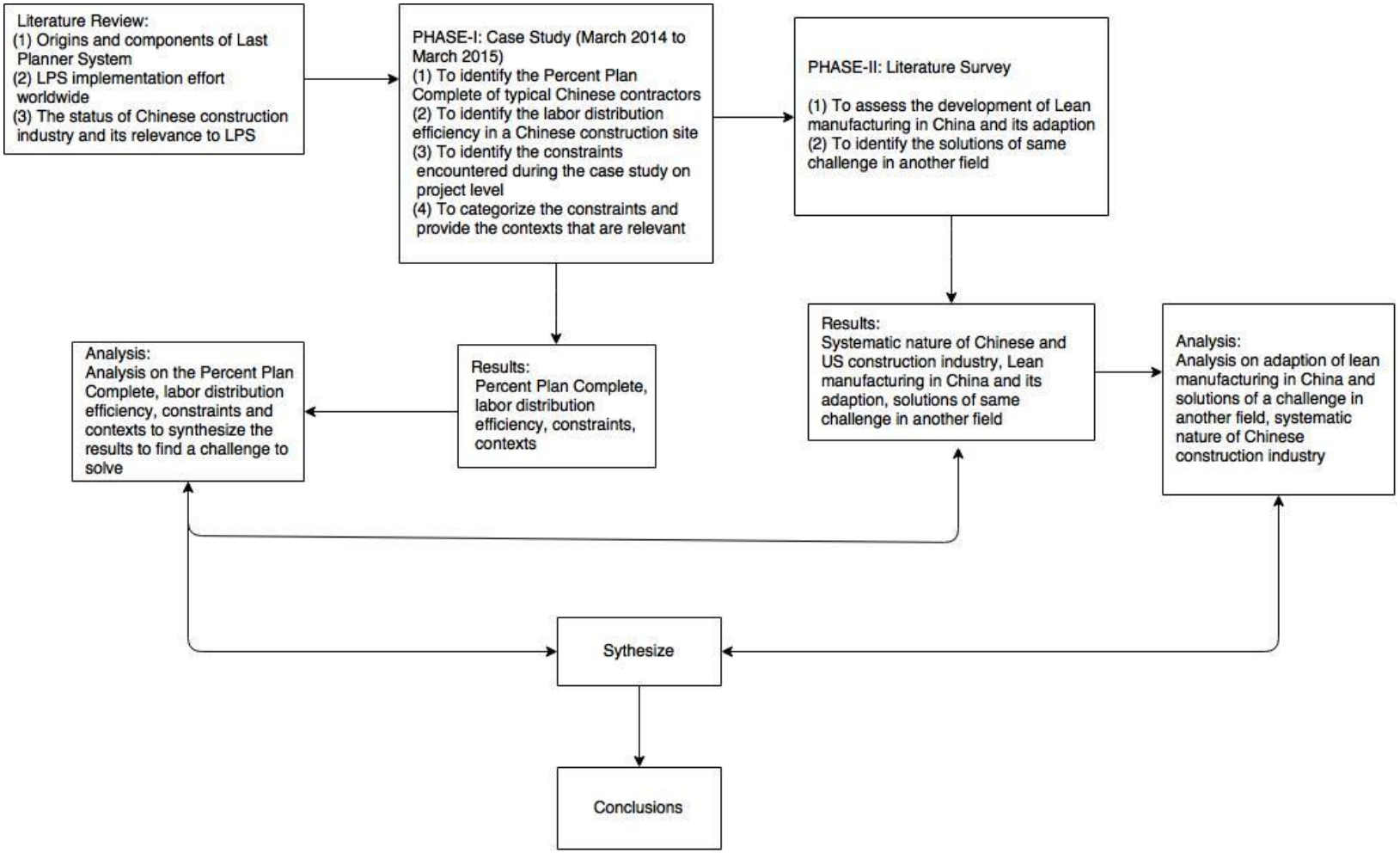

Figure III-1 Research design

3.1 Phase I: Project Delivery Efficiency of Chinese Construction Contractors and Possible Challenges during the Implementation of LPS in China

In order to fill the gap of the exploration of Lean Construction in China, the author carried out an in-depth case study to reveal the status of project delivery in Chinese construction site and identify challenges that might show up during the implementation of LPS. Restricted by time and personnel, the research involved only one case study. Considering the duration of the adaption to the construction site, the data collected in this research was limited to a one month period.

The case study was developed mainly by using the author's family connections as a resource. During the first three months, the author reached out to family connections to find a project that was suitable for conducting this case study. The development of the Chinese construction industry is imbalanced due to the different economic strengths various regions (Liu et al. 2014). To offset the imbalance between less developed regions and developed regions, the author chose a large high-rise residential project with a square footage of 533,265. The general contractor for the project is China Railway Construction Corporation: the 39th general contractor in the world according to ENR (Engineering News Record 2014).

After finalizing the project selection, the author started the case study by adapting to the job site and getting familiar with the daily operation. The time frame for the data collection in this study was initially chosen as two months. However, according to the time required by the adaption process on the job site, the time frame was reduced to one

month. During the case study, Percent Plan Complete was collected to indicate the project delivery efficiency. The author served as the assistant project manager on the job site. Responsibilities of the assistant project manager included accompanying the project manager to the job site in order to check the progress and quality of the work that has been assigned during the planning phase. By comparing the preplanned work found in the project record and the status of real completion, the author was able to accurately calculate PPC to ascertain project-planning reliability. The project records and documents used for the calculation of the PPC are the weekly plan, the daily plan, the daily work log of the project manager, and contract document. The number of working foremen and unoccupied foremen was recorded in Table III-1 to demonstrate the labor efficiency of Chinese contractors. Additionally, constraints encountered during the daily operation were inputted into Table III-2.

Table III-1 Table for recording project delivery efficiency in Phase I

Date	Percent Plan Complete	Working Foremen	Vacant Foremen	Total Foremen

Table III-2 Table for the analyzing constraints found in Phase I

Constraints	Types	Solution	Context

Although the value of LPS has been validated by using surveys based on construction professional's opinions at a management level, the benchmarking of the contractor practice is hard to find in lean research (Ramírez et al. 2004). A widespread adoption of lean has not happened in most countries, outside the car manufacturing industry (2011). Therefore, the successful implementation of the LPS in one country cannot be applied to a different country without careful validation. More importantly, simply aggregating positive results gained from different case studies cannot provide an actual state of LPS implementation on site and how the LPS can be applied at a project level. On the contrary, researchers encourage the use of empirical data to test and validate a framework (Gao and Low 2014). Therefore this study obtained the project delivery data and record from the construction site to reflect the status of Chinese contractors during the daily operation, thus offering solutions on how LPS can be better applied in a Chinese construction site.

3.2 Phase II: Solutions Found in other Fields

The progress of this phase depended on the results found in the previous phase. Hence the scope of the literature review was divided into two parts:

1. Development of Lean manufacturing in China and its adaption
2. Solutions from other fields in regard to the one challenge found in the phase I

Then according to the three fields listed above, the author identified databases such as journals, conference proceedings, books and theses. These databases included but were not limited to the *International Journal of Production Economics*, the *International Group for Lean Construction*, *Lean Construction Institute*, *Journal of Managerial Psychology, Journal of Experimental Social Psychology, Journal of Construction Engineering and Management, Academy of Management Journal, Architectural Engineering and Design Management, International Journal of Project Management, The International Journal of Human Resource Management, KSCE Journal of Civil Engineering, Journal of Applied Psychology, Journal of Management in Engineering, Journal of Business Venturing,* and the *Canadian Journal of Civil Engineering*.

Since very little effort has been made on the implementation solutions of the LPS in China, the author hopes to offer strategies for implementation by combining the findings from the case study and the literature review.

Restricted by the time frame, the scope of the literature review mainly focuses on the systematic nature and challenges that are relevant to the LPS implementation in China, and the results are further filtered according to the findings of the case study. The

author compares the results from the case study and the literature review to provide an overall view of implementing the LPS in China and practical implementation strategies that are suitable for Chinese contractors.

The researchers around the globe have conducted more than 200 case studies since 1996. However, considering the time frame is 19 years and the pilot projects are distributed all over the world, not a single country can provide enough evidence of successful widespread adoption. Therefore the aggregation of successful implementation in different countries does not shed much light on the implementation of LPS in other countries. Strategies worked in one country may not apply to other countries. Nevertheless, contractors are more inclined to have faith in a practice-based methodology. Scholars should strive to fill the gap between the academic environment and the industry environment (da C. L. Alves et al. 2012) . Chinese contractors who build high-rise residential buildings in the same area might consider the findings of this research useful.

3.2.1 Limitations

Since this research only investigates one case study in the southwestern region of China, the generalizability of this study to a larger population awaits further exploration. Moreover, collecting data for one month is not enough for the researcher to observe the trend of PPC and constraints over the entire construction period.

CHAPTER IV

DATA ANALYSIS

4.1 Phase I: Results from the Case Study

4.1.1 Power Structure

The first step of initiating a case study in China is establishing the personal relationships with the staff on the job site. Personal connections usually weigh more than technical skills in the Chinese construction industry. To achieve the first step, getting familiar with the power structure at the construction site is a prerequisite. Unlike U.S. general contractors, the power structure of Chinese general contractors is divided into four layers. The first layer of the power structure consists of the execution manager and the chief engineer. The execution manager wields the most power on the job site including monitoring the progress of the project delivery, supervising all management personnel, and coordinating different subcontractors. The other individual who holds the most power at the construction site is the chief engineer; the chief engineer handles the engineering problems that appear in a project and oversees quality control of the daily operation. Since the execution manager and the chief engineer are at the first layer of the Chinese construction power structure, their presence at the job site is not mandatory. The role of the chief engineer, which has no equivalence in the U.S. construction industry, usually demands handling multiple projects at the same time. Hence the chief engineer may only come to the job site once a week. Only the individuals who function within the first layer of the power structure have the chance to talk to the CEO of the company.

At a Chinese construction site, even though the project managers are at the second layer of the power structure, they bear the most responsibilities. The presence of the project manager is mandatory on the project site. The project manager in China entails the responsibilities of both the project manager and the superintendent in the U.S. construction industry. Detailed tasks such as overseeing the daily operation, monitoring the quality of finished work and solving detailed engineering problems on the job site are assigned to the project manager. On this case study project, the project manager, to some extent, did part of the work that was supposed to be done by the execution manager and chief engineer. What seemed more important for them was to network with the high-ranking management personnel from different parties since deals are usually made after drinking on dinner parties. When the opinions of the project manager are in conflict with the execution manager or the chief manager, the people at the first layer of the power structure overrule the people from the second layer even if the project manager from the second layer is more familiar with daily operations.

At the third layer of the power structure lies all the other management personnel including quality controller, safety manager, material handler, electrical engineer and HVAC engineer. The individuals who function in this layer are participants in the planning process. Although they inhabit a lower level of the power structure, they are still well aware of the overall progress of the project.

Finally at the bottom layer of the power structure lies the foremen. They are skilled labors with years of experience from different projects. The only thing they care about is to get the work done in the given time to ensure survival; they have no idea how

the project is faring at a management level. On this case study project, the construction workers were divided into different teams: concrete team, steel team and lumber team, with a team leader in each team. Most foremen may lack the capability to analyze where they are now in the project flow (Gao and Low 2014). The team leaders of foremen were equipped with the ability to read blueprints, supervise the team's progress, and coordinate with the project manager. They have the capabilities to be engaged in the planning process and take the role of "last planners". The figure IV-1 shows the power structure of the Chinese general contractor at the job site.

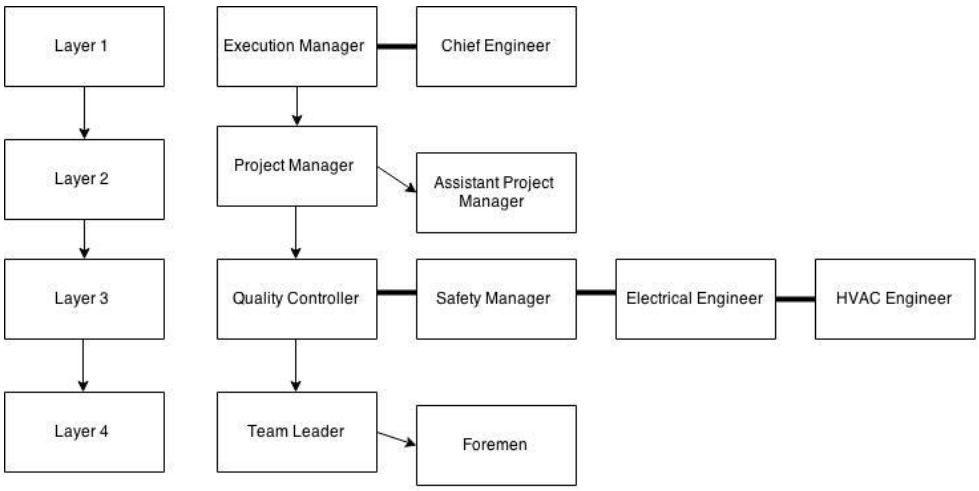

Figure IV-1 Power structure of the Chinese general contractor on site

4.1.2 Constraint Analysis

A constraint analysis was originally carried out to analyze the root-causes of non-completion, thus establishing an environment for continuous improvement. In this research, the constraint analysis was used to identify the challenges and constraints Chinese contractors have that impede the implementation of the LPS. As stated above, the author served as an assistant project manager, whose job was to accompany the project manager to do the job site visits every day, thus checking on the progress of the project, supervising foremen's work, and coordinating different subcontractors. Then the assistant project manager was required to write notes on the work log after daily operation. Each person from the management team has a work log to record daily activities.

At the start of each workday, a detailed plan indicating the amount of work to be done was handed out to the management personnel. Detailed quality requirements of the project were also given to the project manager and other management staff on site. The project manager and the assistant project manager were required to finish writing the work log after daily activities so as to provide details for future reference. Additionally, the author recorded details of unfinished and unsatisfactory work during site visits. Then constraints were identified by analyzing the work log and the author's notes on the job site. These were inputted into Table IV-1, which shows the constraints, types, solutions and elements of context.

Table IV-1 Constraint analysis from the case study

Constraint	Type	Solutions	Context
Lack of steel pipe fastener	Material Procurement		
Uneven plastering	Unspecified requirements		
Unfinished plastering	Personnel on the way		
Unattended bricklaying zone	Personnel Distribution		
Unable to unload the rebar	Material procurement		
Rebar is too big to lift by tower crane	Material Procurement		
Truck stuck at the entrance	Material Procurement		
Lack of brick	Material Procurement		
Lack of intercom for tower crane	Equipment Procurement		
Excess concrete around anti-floating anchor rod	Workers Skill		
Random placing of backfill materials	Unspecified requirements		
Unable to use the tower crane	Permits acquisition		
Collapse of the brick wall	Conflicts of power		
Raining	Weather		
Lack of backfill material in the trench leading to difficulty in pouring concrete	Unspecified Requirements		
Slippery passage in the rain leading to tumbling of workers	Safety		
Unable to install the light on the tower crane, both sub and general seek to shirk the responsibility	Conflicts of power		
Project manager wasted time to teach ground workers fundamentals	Workers Skill		
Labor distribution depending on the tower crane	Personnel Distribution		

Table IV-1 Continued

Constraint	Type	Solutions	Context
Enclosing of brick wall in the trench	Worker's Skill		
Deadline Pushing	Schedule		
Too much space around the anti-floating rod	Worker's Skill		
Garbage left in the pit	Unspecified Requirements		
Price over quality subcontractor selection	Subcontractor		
Lack of backfill material	Unspecified Requirements		
Underground water draining in the pit	Lack of Preplanning	Dig up a blind drain, drain the water toward one direction, pump out the remaining water, fill the wall on pit with plugging agent	The so called "technical director couldn't come up with a solution
Leaving too much space when doing the masonry wall of the foundation pit	Conflicts of opinions	Didn't even decide on the construction methods before the project started	
Bearing wall of foundation is not finished, making it impossible to pour concrete	Lack of Preplanning	Foremen have absolutely no idea where the work is at now	
Had no idea how much brick and rebar are needed	Lack of Forecasting	Also unspecified responsibility	
Had no idea whether sandbag was bought	Laziness		
Workers had a problem finding insulation gloves	Safety Management		
Steel treating zone was not completed on schedule	Schedule		
The temperature was too high for foremen	Weather		Weekly plan is updated, incoming the monthly plan
Raining cause water seepage	Weather		Inputs lacked from foremen

Table IV-1 Continued

Constraint	Type	Solutions	Context
Throwing steel tube randomly on the job site	Lack of Preplanning		
Overworking at night to catch up with the schedule	Institutional Failure		Nearly working every night for a week
Contractor violation of subcontractors	Institutional Failure		
Subcontractors in violation of safety rules and unable to cooperate	Institutional Failure		
No place for workers to rest or drink water	Lack of Preplanning		
The fence was blown down	Lack of Preplanning		
The concrete bulk around the anchor rod was not cleared	Unspecified Requirement		
The plaster layer around the anchor rod was not done clearly	Worker's Skill		
Laitance spread all over the rebar	Worker's Skill		Shirk responsibilities from each other
No plaster on the edge of bearing platform	Worker's Skill		
Garbage on the jobsite	Unspecified Requirement		
Started bricklaying without checking the excavated trench first	Worker's Skill		Gave instructions clearly many times
Foremen handling the scaffold didn't know where to paint	Lack of Forecasting	Multi-layer of subcontractors caused waste of time by negotiating on site	Also institutional failure, rarely following the contract
Pouring concrete onto the post cast strip	Unspecified Requirement		

Table IV-1 Continued

Constraint	Type	Solutions	Context
Forgot to leave a hole around the anchor rod when pouring the concrete	Unspecified Requirement		
Water ponding in the foundation pit	Conflicts of power		Subcontractor want to protect the water pump
Failed to deliver the R angle around the corner of post cast strip	Worker's Skill Unspecified Requirement Conflicts of power		
Unable to use the crane	Subcontractors		
Had problems unloading the waterproofing material which weighs over 50 kg (110 lbs.)	Material procurement		
Neither bricklaying the post cast strip nor measuring the layout	Laziness		
Pouring concrete without bricklaying	Schedule		
Pouring concrete onto the position where post cast strip was going to be built	Unspecified requirement		Sticking to the deadlines in regardless of how much mess has been made
Conflicts between the general and the sub	Institutional failure		People skill is critical.

Note that the "type" column was extracted from Table IV-1 and used to generate Table IV-2. The table shows the frequency of each type of constraint that showed up during the case study.

Table IV-2 Frequencies of each type of constraint

Type of Constraint	Quantities
Unspecified requirements	12
Workers Skill	8
Lack of Preplanning	8
Material Procurement	6
Conflicts of power	4
Institutional Failure	4
Safety Management	3
Weather	3
Schedule	3
Personnel	3
Subcontractor	2
Equipment Procurement	1

4.1.3 Exclusion of Foremen during the Planning Process

The constraint that appeared the most in this case study was the "unspecified requirements" category. It indicated that the foremen were seldom involved in the planning process to be informed of the quality requirements that specifically applied to the project. Foremen, led by the team leader, simply performed the set tasks they had accomplished in the previous projects. The results also reflect the fact that because the subcontractors and foremen are seldom involved in the pre-planning process, the burden of overseeing the quality falls on the shoulders of the project manager. The project manager had no choice but to repeat the quality requirements over and over again to all the foremen on the construction site.

However, the findings from the case study indicate that trade foremen have the capability to do individual work well. Although they are not capable of controlling the

flow of the entire project, the team leaders of different labor forces can serve as last planners to join the planning process, and in turn can train their own men to become familiar with the quality requirements of the project. Hence the second indicator of this project, "worker's skills," does not imply that foremen were incapable of craftwork. Instead, because of their labor skills accumulated from the previous projects, they were accustomed to traditional processes, and the team leader failed to train them to adjust to the individual requirements of each project.

4.1.4 No Update on the Planning Information

Lack of preplanning is another important constraint that was revealed in Table IV-2. In this case study, the contractor established four levels of planning: the master plan, the monthly plan, the weekly plan and the daily plan. The master plan only specified the major milestones of the project and was divided into different phases. The monthly plan provided an overview for all the tasks that need to be done in a four-week period. Unlike the look-ahead plan specified in the LPS, the monthly plan was recorded after its completion. No attempt was made on the monthly plan to accommodate the changes made in the project. The habit formed in the process of using the monthly plan is detrimental if the look-ahead plan is going to be used in the future implementation of LPS in China. Therefore the monthly plan was not a substitute for the look-ahead plan. Likewise, the master plan was of little value to the project team as well since no updates had been made during the process of construction. On the contrary, the weekly plan and daily plan were valuable for the project management team. A weekly plan was made to inform the project team of detailed work processes.

However, in this research, the author found that the weekly plan was not developed by the project manager who was at the job site every day, but by the chief engineer whose presence at the job site was not mandatory. As a result, little update was made manually to adjust the weekly plan. The project manager had to adjust the weekly plan according to his own experience and feedback collected during the weekly meetings, thus overwhelming the project manager with a tremendous amount of coordination work among the different parties.

4.1.5 Lack of Cooperation among Different Parties

Another two factors worth discussing include: “institutional failure” and “conflicts of power.” Subcontractors were excluded from the planning process and the burden of adjusting the plan fell on the shoulder of the project manager. Therefore the project manager was forced to readjust the schedule, labor and subcontractors over and over again. On the other hand, since subcontractors have little influence on the project planning process, it was not possible to establish trust between general contractors and subcontractors, which not only caused conflicts of power between different subcontractors, but also generated additional coordination work for the project manager.

On the labor side, construction workers are often treated as machines instead of valuable assets needed for the company’s continuous improvement. The trade foremen are forced to work at the construction site throughout the year, including most holidays and weekends. The only time these employees can go home is during the spring festival, when they are finally able to spend time with their families. Furthermore, constant overwork required by the general contractor to catch up with the project schedule is also

a challenge that will need to be addressed if project teams wish to establish the more harmonious working environment that Lean construction encourages.

4.1.6 Percent Plan Complete (PPC)

PPC is one of the key indicators of the Last Planner System used for tracking the project planning reliability. The usage of PPC in this research was mainly for exposing the challenges of LPS implementation. To calculate an accurate PPC, the researcher needed to first identify and count the number of tasks that were supposed to be completed according to the plan and then the number of tasks that were actually completed during construction. The construction documents including the weekly plan, daily plan and the notes from site visits are the source of getting the right number of assigned tasks. During site visits, the researcher crosschecked with the project manager to determine the status of real completion. After daily operations, the researcher divided the number of tasks that were completed by the number of tasks that were supposed to be completed, times 100, in order to arrive at PPC value (as a percentage). Table IV-3 includes the PPC collected during a one-month time period.

Table IV-3 Results for Percent Plan Complete

Date	PPC	Working Foremen	Idle Foremen	Total
21-May	31%	24	6	30
22-May	40%	25	5	30
23-May	41%	35	5	40
24-May	20%	9	0	9
25-May	35%	32	5	37
26-May	22%	21	5	26
28-May	40%	4	32	36
29-May	42%	38	8	46
30-May	41%	31	6	37
31-May	19%	7	3	10
1-Jun	25%	26	4	30
4-Jun	19%	36	8	44
5-Jun	24%	48	8	56
6-Jun	27%	34	9	43
7-Jun	30%	28	3	31
8-Jun	35%	15	0	15
10-Jun	33%	32	7	39
13-Jun	43%	56	10	66
14-Jun	42%	54	12	66
16-Jun	45%	55	0	55
18-Jun	12%	12	5	17
19-Jun	17%	15	5	20
20-Jun	16%	9	0	9
21-Jun	37%	35	6	41
22-Jun	17%	9	2	11
23-Jun	18%	8	6	14
25-Jun	22%	22	4	26

As indicated in the previous discussion, personnel distribution is also one of the constraints found in this case study. To further understand the phenomenon, the researcher also recorded the number of working foremen and unoccupied construction workers.

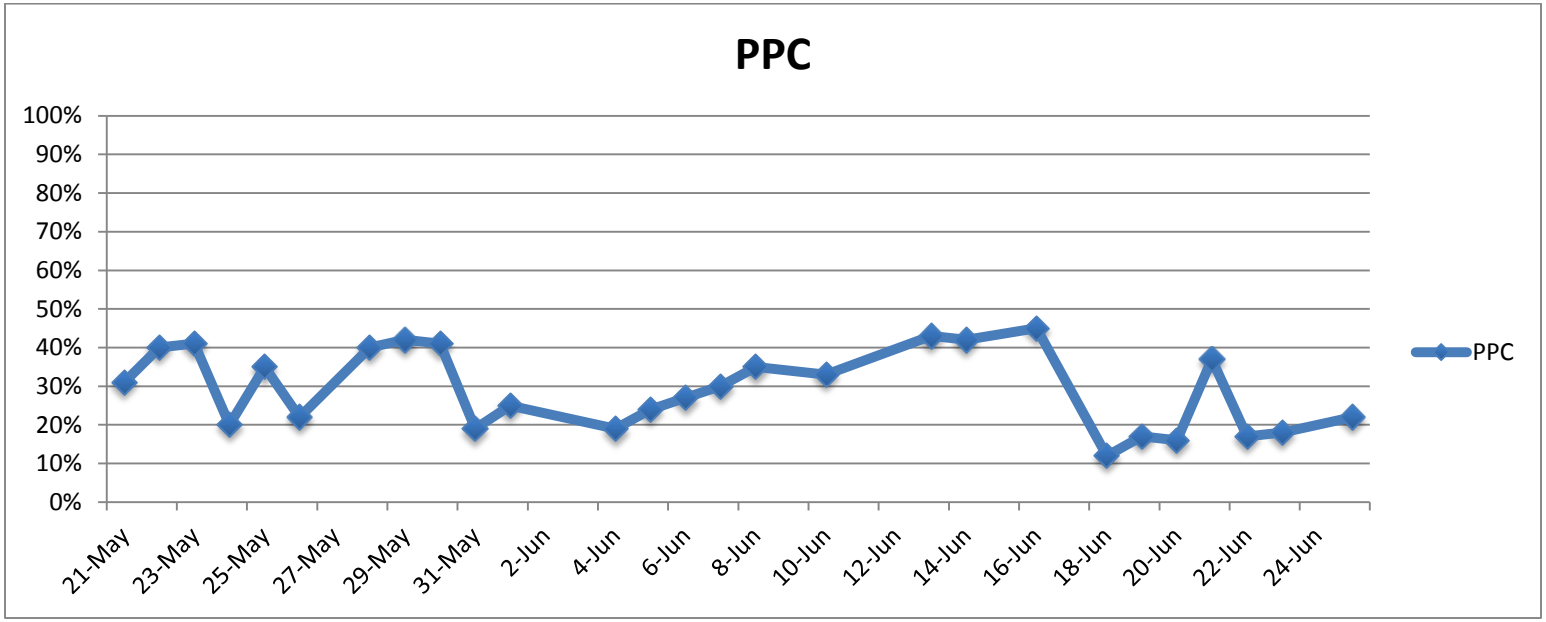

Figure IV-2 The trend of PPC during a one month period

The line graph in Figure IV-2 depicts the trend of PPC during a one-month period. From the figure we can see that the graphed line is unstable and volatile, which reflects the unreliability of the planning system utilized by Chinese contractor. This finding also corroborates the results found in the previous discussion: the exclusion of foremen in the planning process, no update on the planning information, and lack of cooperation between different parties--causing the project manager to constantly readjust labor and resources. The spikes found in the figure were caused by overburdening construction workers. Owing to the unreliable planning system, the project team needed to compress activities within the project schedule much of the time. To catch up with the planned schedule, the foremen were forced to work overtime to meet deadlines, thus accomplishing a large number of tasks in one day. The lowest values of PPC were recorded on the days that had rainfall. The case study was conducted in the southwest part of China, where rain was expected regularly in summer.

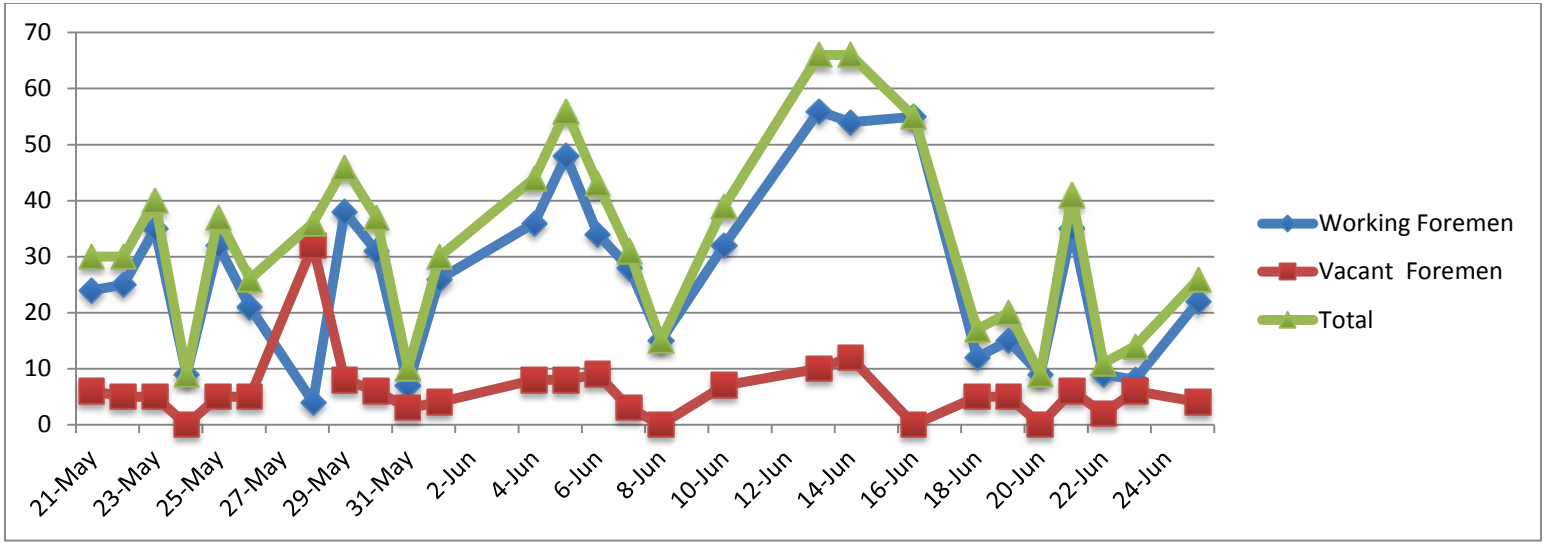

Figure IV-3 The trend of working and idle foremen during one-month period

Figure IV-3 indicates that there were always unoccupied foremen who were working below capacity. One of the reasons for this idle behavior may be that these foremen were likely trained to follow the same procedure over different projects. Once they were assigned to a new project, due to the overburden of the project manager, as well as detachment between the general contractors and subcontractors, they were never given instructions on how to adjust their work to the differing conditions of the new project. Figure IV-3 also suggests that the trend of planning reliability does not necessarily coincide with the trend of foremen throughout the entire one-month period. The days with a small number of foremen and a high PPC supports the fact that the Chinese foremen are hardworking skilled who is committed to tasks.

4.1.7 Summary

The results from the constraint analysis revealed three major challenges that may impede progress of implementation of LPS in China:

- Exclusion of foremen during the planning process;
- No regular updates on planning information; and
- Lack of cooperation among different stakeholder parties

From the case study, the author corroborates the results found in the previous study that Chinese construction workers have poor capabilities of seeing the bigger picture (Gao and Low 2014). However, trade foremen have the desire to complete work in time to meet deadlines, thus ensuring their own survival. The team leaders of foremen very likely have the ability to understand the overall project flow, if given more freedom in the power structure. In this case study, the failure to involve foremen and subcontractors contributed to a lack of cooperation among different stakeholder parties. The absence of foremen and subcontractors in the planning process loaded all planning responsibilities onto the project manager, who repeatedly adjusted the resources and the labor according to his previous experience.

To analyze the larger picture, the author encourages the reader to view these construction challenges from the perspective of the power structure of Chinese general contractors. The problem did not fall on the power structure inside the general contractor. Although the trade foremen were rarely given the opportunity to offer their input to the execution manager and the chief engineer, they interacted frequently with the individuals within the second and the third layers of the power structure. The project manager

already established a trusting relationship with the foremen by using leisure time to make personal connections, which laid a foundation that could foster a lean environment. The greatest challenge resided in the power distance observable between different parties since the interaction among general contractors, subcontractors and foremen was scarce. Given the constraints of a Chinese construction worksite, reducing the power distance between different parties is a prerequisite for implementation of the Last Planner System in China.

4.2 Phase II: Results from Literature Review

4.2.1 Lean Manufacturing in China and its Adaption

The origins of Lean Production dates back to 1970s, when the automotive industry first utilized the technique (Taj 2008). As the economic growth of China has been fast and stable over the past three decades, companies all over the world have been establishing branches in China due to low wages and the "Reform and Open Policy." As the number of companies in China grow every year, enterprises try to utilize the lean approach to stay competitive.

The first Chinese automotive plant in Changchun--First Automotive Works (FAW)--was established in 1953. In 1977, with the help of Taiichi Ohno, FAW became the first enterprise to utilize the Toyota Production System outside of Japan--which was earlier than the application of Lean Production in American and European companies. Interestingly, Ohno, the father of Toyota Production System, was actually born in China. The cooperation between Taiichi Ohno and FAW provided a prototype for initiating Lean Production—a joint venture between Chinese companies and parties from other

countries. The later joint venture between Shanghai Automotive Industry Corporation (SAIC) and Volkswagen (VW) was proven to be one of the most successful companies in the Chinese automobile manufacturing history (Chen et al. 1997).

Efforts of implementing lean were also made in other areas of China. According to Wong (2007), top managers should personally take the lead during project meetings, projecting ambition and vision to their employees, thus helping to change the existing company value system. In addition, short-term incentives are needed early on. Help from external experts along with a clear vision from the manager at the first level could create sufficient momentum to reduce power distance and ease implementation of lean (Wong 2007).

4.3 Power Distance

The table in the Appendix provides results from a literature review on power distance. Findings from the literature review indicate that empowerment has the ability to reduce power distance. However, during the process of transition, this type of empowerment should be initiated from the top, and not the other way around; this is consistent with findings from the previous literature review.

CHAPTER V

CONCLUSIONS AND STRATEGIES

Although the Lean Construction Institute has established branches all over the world, a local LCI office in Mainland China has not yet been officially established—indicating the current status of Lean Construction in China. In fact, the term "Lean Construction" is hardly known among Chinese construction professionals. This thesis is arguably the first study to explore the potential of LPS implementation in China at a project level. By conducting a case study exploration, the researcher uncovered unique challenges of Chinese culture that would likely impede the implementation process of LPS in China. The results generated during this case study share some common ground with findings from the previous survey exploration on the perception of Chinese construction professionals toward the LPS. Generally, both studies refer to a similar hierarchical planning system in China.

However, differences have to be addressed in order to determine possible implementation strategies. The reason why Chinese construction workers are not involved in the planning process is not because of their poor capabilities. In fact, several factors of lean implementation have already been in place at most job sites: For example, most project managers do establish a trusting relationship with their foremen and are willing to listen to their input. Although their input might not influence the overall progress of the project, their team leaders have the ability to serve as the last planner to collect feedback from the bottom layer of the power structure, thus improving a project's

flow. Additionally, although a four-phased planning system is already utilized by Chinese contractors, there is no look ahead plan to conduct a constraint analysis and measure planning reliability by calculating PPC. This exploratory research suggests that obtaining PPC in industrial settings of China is possible. Neither tight schedule nor inadequate management efforts need to be an excuse. Methods used for calculating PPC and conducting constraint analysis in this research can serve as a reference for future researchers. Furthermore, the problem of high power distance does not occur inside one entity or level of hierarchy, but instead between entities and levels of hierarchy. The Chinese project team consists of three different parties: general contractors, subcontractors and labor companies. Resistance from the high power distance culture mainly comes from connection between different entities. A lack of trust between the general and the subcontractors could hamper the implementation of LPS in China. Combining results from the literature review and case study site observations, strategies to implement LSP in China are proposed:

- Top management personnel occupying the first layer of the power structure (e.g. general contractor, subcontractor and trade partners) should congregate before the project begins and declare a vision for the project. All the players should define clear scopes of management responsibility. Given the high power distance culture in China, this change can be accomplished by having the individuals occupying the first layer give orders to the personnel at the next lower level. The project manager from the contractor's side is encouraged to cooperate with subcontractors to refine the preplanning process. The vision and ambition displayed by the top management

personnel can inspire sufficient momentum to reduce the power distance between different entities. This step is a prerequisite for establishing trust between general contractors and subcontractors.

- With the authorization from the first layer of the power structure, empowerment can be inspired by the personnel at the second layer of the power structure. Foremen should be encouraged to provide input to management personnel, especially when the input has relevance to the planning process. An open and trusting environment can be created during the transformation process.
- PPC should be integrated into the planning system utilized by Chinese contractors. This research represents pioneering work on applying PPC to measure project reliability with minimal human resources in China. The other missing component of Last Planner System--constraint analysis--should also be undertaken to examine the root causes of unfinished and unsatisfactory work. Both tools can serve as a constant reminder of the need to update planning information, so that performance of the weekly plan can be tracked and improved.
- The team leaders of the labor force in China would be appropriate to serve as "last planners."
- Team leaders should be encouraged to be involved in the planning process to interact with other players of the project. They can determine appropriate levels of workload and report this to the project manager, which will ease the responsibilities of the project manager. Proper incentives should be offered to the team leaders of labor force.

REFERENCES

Ala-Risku, T., and Kärkkäinen, M. (2006). "Material delivery problems in construction projects: a possible solution." *International Journal of Production Economics*, 104(1), 19-29.

AlSehaimi, A. O., Tzortzopoulos, P., and Koskela, L. (2009) "Last planner system: Experiences from pilot implementation in the Middle East." *Proc., Proceedings of the 17th Annual Conference of the International Group for Lean Construction*, 53-65.

Ballard, G. (1994). "The last planner." *Northern California Construction Institute, Monterey, California*.

Ballard, G., and Howell, G. (1998). "Shielding production: essential step in production control." *Journal of Construction Engineering and Management*, 124(1), 11-17.

Ballard, G., and Howell, G. A. (2003) "An update on last planner.", *Proc., 11th Annual Conf., International Group for Lean Construction, Blacksburg, VA*.

Ballard, H. G. (2000). "The last planner system of production control." The University of Birmingham, Birmingham, UK.

Barbosa, G., Andrade, F., Biotto, C., and Mota, B. (2013) "Implementing lean construction effectively in a year in a construction project." *Proc., Proceedings for the 21st Annual Conference of the International Group for Lean Construction, Fortaleza, Brazil*, 1017-1026.

Begley, T. M., Lee, C., Fang, Y., and Li, J. (2002). "Power distance as a moderator of the relationship between justice and employee outcomes in a sample of Chinese employees." *Journal of Managerial Psychology*, 17(8), 692-711.

Brockner, J., Ackerman, G., Greenberg, J., Gelfand, M. J., Francesco, A. M., Chen, Z. X., Leung, K., Bierbrauer, G., Gomez, C., and Kirkman, B. L. (2001). "Culture and procedural justice: The influence of power distance on reactions to voice." *Journal of Experimental Social Psychology*, 37(4), 300-315.

Cerveró-Romero, F., Napolitano, P., Reyes, E., and Teran, L. (2013) "Last Planner System® and Lean Approach Process®: Experiences From Implementation in Mexico." *Proc., 21st Annual Conference of the International Group for Lean Construction, IGLC*, 709-718.

Chan, D. M., Chan, A. P., Lam, P. T., Lam, E. W., and Wong, J. M. (2007). "Evaluating guaranteed maximum price and target cost contracting strategies in Hong Kong construction industry." *Journal of Financial Management of Property and Construction*, 12(3), 139-150.

Chen, J., Lee, C., and Fujimoto, T. (1997). "Adaptation of lean production in China: the impact of the Japanese management practice." *CIRJE/International Research, CIRJE F-Series on the Japanese Economy, Faculty of Economics, the University of Tokyo, Tokyo*, 97-27.

Chen, P., and Partington, D. (2004). "An interpretive comparison of Chinese and Western conceptions of relationships in construction project management work." *International Journal of Project Management*, 22(5), 397-406.

Chen, Y. Q., Liu, J. Y., Li, B., and Lin, B. (2011). "Project delivery system selection of construction projects in China." *Expert Systems with Applications*, 38(5), 5456-5462.

Choo, H. J., Tommelein, I. D., Ballard, G., and Zabelle, T. R. (1999). "WorkPlan: Constraint-based database for work package scheduling." *Journal of Construction Engineering and Management*, 125(3), 151-160.

da C. L. Alves, T., Milberg, C., and Walsh, K. D. (2012). "Exploring lean construction practice, research, and education." *Engineering, Construction and Architectural Management*, 19(5), 512-525.

Daniel, E. I., Pasquire, C., and Ameh, O. J. (2013). "The magic of the Last Planner System for Nigerian Construction," *21st Annual Conference of the International Group for Lean Construction*, Fortaleza, Brazil.

Egan, J. (1998). *Rethinking construction*, Department of Environment, Transport and the Region.

Farh, J.-L., Hackett, R. D., and Liang, J. (2007). "Individual-level cultural values as moderators of perceived organizational support–employee outcome relationships in China: Comparing the effects of power distance and traditionality." *Academy of Management Journal*, 50(3), 715-729.

Fernández-Solís, J. L. (2008). "The systemic nature of the construction industry." *Architectural Engineering and Design Management*, 4(1), 31-46.

Fernandez-Solis, J. L., Porwal, V., Lavy, S., Shafaat, A., Rybkowski, Z. K., Son, K., and Lagoo, N. (2012). "Survey of motivations, benefits, and implementation

challenges of last planner system users." *Journal of Construction Engineering and Management*, 139(4), 354-360.

Gao, S., and Low, S. P. (2014). "The Last Planner System in China's construction industry—A SWOT analysis on implementation." *International Journal of Project Management*, 32(7), 1260-1272.

Gao, S., and Low, S. P. (2014). "The Toyota Way model: an alternative framework for lean construction." *Total Quality Management & Business Excellence*, 25(5-6), 664-682.

Hamzeh, F. R., and Aridi, O. Z. (2013) "Modeling the Last Planner System metrics: A case study of an AEC company." *Proc., Proc., 21th Annual Conf. of the Int. Group for Lean Construction (IGLC-21), International Group of Lean Construction, Fortaleza, Brazil*.

Hofstede, G. (1980). "Culture and organizations." *International Studies of Management & Organization*, 15-41.

Humborstad, S. I. W., Humborstad, B., Whitfield, R., and Perry, C. (2008). "Implementation of empowerment in Chinese high power-distance organizations." *The International Journal of Human Resource Management*, 19(7), 1349-1364.

Huovila, P., and Koskela, L. (1998)"Contribution of the principles of lean construction to meet the challenges of sustainable development." *Proc., 6th Annual Conference of the International Group for Lean Construction. Guaruja, São Paulo, Brazil*, 13-15.

Kenley, R., and Seppänen, O. (2006). *Location-based Management System for Construction: Planning, Scheduling and Control*, Routledge.

Kirkman, B. L., Chen, G., Farh, J.-L., Chen, Z. X., and Lowe, K. B. (2009). "Individual power distance orientation and follower reactions to transformational leaders: A cross-level, cross-cultural examination." *Academy of Management Journal*, 52(4), 744-764.

Koskela, L. (1992). *Application of the new production philosophy to construction*, Stanford University, Stanford, CA.

Koskela, L. (1999) "Management of production in construction: a theoretical view." *Proc., Proceedings of the 7th Annual Conference of the International Group for Lean Construction*, Berkeley, California, USA.

Koskela, L. (2011). "Fifty years of irrelevance: the wild goose chase of management science." *Proceedings IGLC-19 (International Group for Lean Construction)*, 85-96.

Koskela, L., and Ballard, G. (2006). "Should project management be based on theories of economics or production?" *Building Research & Information*, 34(2), 154-163.

Le, Y., Shan, M., Chan, A. P., and Hu, Y. (2014). "Investigating the causal relationships between causes of and vulnerabilities to corruption in the Chinese public construction sector." *Journal of Construction Engineering and Management*, 140(9).

Leal, M., and ALARCÓN, L. F. (2010) "Quantifying impacts of last planner implementation in industrial mining projects." *Proc., Proceedings of the 18th Annual Conference of the International Group for Lean Construction, Haifa, Israel*, 518-526.

Liang, K.-G. (2000). "Fairness in Chinese organizations." ProQuest Information & Learning.

Liu, B., Chen, X., Wang, X., and Chen, Y. (2014). "Development potential of Chinese construction industry in the new century based on regional difference and spatial convergence analysis." *KSCE Journal of Civil Engineering*, 18(1), 11-18.

Liu, M., and Ballard, G. (2009) "Factors affecting work flow reliability—A case study." *Proc., Proc., 17th Annual Conf. of the Int. Group for Lean Construction (IGLC-17)*.

Naoum, S. G. (2012). *Dissertation research and writing for construction students*, Routledge.

Nieto-Morote, A., and Ruz-Vila, F. (2011). "Last planner control system applied to a chemical plant construction." *Journal of Construction Engineering and Management*, 138(2), 287-293.

O'Connor, N. G. (1995). "The influence of organizational culture on the usefulness of budget participation by Singaporean-Chinese managers." *Accounting, Organizations and Society*, 20(5), 383-403.

Pasquire, C. L., and Connolly, G. E. (2003) "Leaner construction through off-site manufacturing." *Proc., Proc. 11th Annual Conference, International Group for Lean Construction, Gramado, Brazil*, 263-266.

Pavez, I., and Alarcón, L. F. (2008) "Lean Construction Professional's Profile (LCPP): implementation in Chilean contractor organizations." *Proc., Proceedings of International Group for Lean Construction 16 th Annual Conference, Manchester, UK*.

Ramírez, R. R., Alarcon, L. F. C., and Knights, P. (2004). "Benchmarking system for evaluating management practices in the construction industry." *Journal of Management in Engineering*, 20(3), 110-117.

Robert, C., Probst, T. M., Martocchio, J. J., Drasgow, F., and Lawler, J. J. (2000). "Empowerment and continuous improvement in the United States, Mexico, Poland, and India: predicting fit on the basis of the dimensions of power distance and individualism." *Journal of Applied Psychology*, 85(5), 643.

Rybkowski, Z. K., Abdelhamid, T., and Forbes, L. (2013). "On the back of a cocktail napkin: An exploration of graphic definitions of lean construction," *Proceedings of the 21st annual conference for the International Group for Lean Construction*; July 31-August 2, 2013: Fortaleza, Brazil, 83-92.

Salem, O., Solomon, J., Genaidy, A., and Minkarah, I. (2006). "Lean construction: From theory to implementation." *Journal of management in engineering*, 22(4), 168-175.

Seddon, J., O'Donovan, B., and Zokaei, K. (2011). "Is lean a waning fad?" *Management services : journal of the Institute of Practitioners in Work Study, Organization and Methods*, 55(4), 34-37.

Seppänen, O., Ballard, G., and Pesonen, S. (2010). "The combination of last planner system and location-based management system." *Lean Construction Journal*, 6(1), 43-54.

Shane, S. (1993). "Cultural influences on national rates of innovation." *Journal of Business Venturing*, 8(1), 59-73.

Taj, S. (2008). "Lean manufacturing performance in China: assessment of 65 manufacturing plants." *Journal of Manufacturing Technology Management*, 19(2), 217-234.

Tan, W., and Chong, E. (2003). "Power distance in Singapore construction organizations: implications for project managers." *International Journal of Project Management*, 21(7), 529-536.

Thomas, H. R., Horman, M. J., de Souza, U. E. L., and Završki, I. (2004). "Closure to "Reducing Variability to Improve Performance as a Lean Construction Principle"

by H. Randolph Thomas, Michael J. Horman, Ubiraci Espinelli Lemes de Souza, and Ivica Zavrski." *Journal of Construction Engineering and Management*, 130(2), 300-301.

Tyler, T. R., Lind, E. A., and Huo, Y. J. (2000). "Cultural values and authority relations: The psychology of conflict resolution across cultures." *Psychology, Public Policy, and Law*, 6(4), 1138.

Wong, M. (2007). "The role of culture in implementing lean production system." *Advances in Production Management Systems*, Springer, 413-422.

Zeng, S., Tian, P., and Shi, J. J. (2005). "Implementing integration of ISO 9001 and ISO 14001 for construction." *Managerial Auditing Journal*, 20(4), 394-407.

APPENDIX

Table Appendix-1 Literature review on power distance

Author	Objectives of Study	Results and Conclusions
Tan and Chong (2003)	Examine factors affecting power distance in Singapore construction organization	An employee-centered approach taken by project managers to involve and allow participation of employees in decision making could be the key response in narrowing existing power distance
Farh et al. (2007)	Examining the effect of power distance and Chinese tradition on relationships between perceived organizational support and work outcomes	Relationships were stronger for individuals scoring low (versus high) on power distance or tradition.
Begley et al. (2002)	Use power distance to predict employees outcomes and distributive justice	Those lower in power distance develop strong relationships with authorities, obviating worries about procedural fairness while leaving expectations distributive justice more tenuous. Those higher in power distance have more distant relationships with superiors, making procedural justice an important concern while reducing expectations of distributive justice
Brockner et al. (2001)	Evaluating magnitude of voice effects varies across cultures	(1). Tendency of people to respond less favorably to low levels of voice was greater in low power distance cultures than in high power distance cultures

Table Appendix-1 Continued

Author	Objectives of Study	Results and Conclusions
Humborstad et al. (2008)	Examining how empowerment can be facilitated in the high power context of China	Empowerment positively leads to higher service willingness and this relationship is mediated by performance-based rewards, and organizational and supervisor support.
Kirkman et al. (2009)	Examine individual power distance orientation and follower 's reactions to transformational leaders	(1). The relationship was more positive when power distance orientation was lower, rather than higher. (2). Country differences did not significantly affect these relationships.
Robert et al. (2000)	Test the fit of empowerment and continuous practice improvement practices with national culture	(1) Empowerment was negatively associated with satisfaction in India but positively associated in another 3 samples. (2)Continuous improvement was positively associated with satisfaction in all samples
Shane (1993)	Examine the effect of the cultural values of individualism, power distance, uncertainty avoidance, and masculinity on national rates of innovation in 33 countries in 1975 and 1980	Rates of Innovation are closely associated with the cultural value of uncertainty acceptance, lack of power and distance and individualism.
O'Connor (1995)	Use Hofstede's cultural dimensions to examine whether differences in organizational culture between local and foreign manufacturing firms affect the usefulness of budgetary participation in a high power distance nation.	Power distance moderates the usefulness of participation in budget setting and performance evaluation at the organizational culture level in terms of decreased role ambiguity and enhanced superior /subordinate relationship.
Liang (2000)	Examining the roles of organizational justice and individual cultural characteristics in affecting employee's work attitudes and behaviors, in particular, the context aspect of job performance in Chinese organizations.	(1)For people with high distance, participation tended to negatively correlate with such job behaviors as task.

Table Appendix-1 Continued

Author	Objectives of Study	Results and Conclusions
Hofstede (1980)	Proposing four dimensions on which the differences among national cultures can be understood: Individualism, Power Distance, Uncertainty Avoidance and Masculinity.	(1) High power distance may promote an indifference to quality of treatment by authorities, since subordinates have lower expectations about respectful treatment
Tyler et al. (2000)		(1)Relational factors are de-emphasized in high power distance cultures (2) Individuals in high power distance cultures may be tolerant of poor treatment of subordinates