POTENTIAL, COMPETITIVENESS AND STRATEGIES FOR IMPLEMENTING LEAN CONSTRUCTION IN THE CONSTRUCTION INDUSTRY IN PAKISTAN

by

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Dedicated

to

My Mother and Late Father

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Table of Contents

List of Tables

List of Figures

Abstract

Lean Construction is one of the major change efforts in construction industry that has been successfully employed in most of the developed countries. It has offered efficient construction practices by reducing the wastes tremendously that have ultimately led to the high quality works being completed in shortest time and cost. Lean construction is inspired from lean production developed by Toyota Motors in Japan after Second World War. However, standardization in lean construction has not still reached its final shape but its effectiveness especially in construction industry has been proved significantly. This thesis determines the potentials and competitiveness of lean construction in the construction industry in Pakistan with strategies to implement.

A questionnaire based on the lean construction model is used to survey the lean construction practices through which lean construction conformance was measured in the construction industry in Pakistan. The questionnaire was designed based on the models presented by the researchers which included 5 topmost principles and 16 sub-principles of lean construction. For each sub principle, questions based on lean practices and their anticipated importance in the construction industry, were developed to assess the lean conformances and importance level based on the likert scale. The importance for lean practices in the construction industry and lean conformance explored the potential available in Pakistan for lean construction. The questionnaire was pilot tested after discussing with the experts in the construction industry as well as Academia. The sample size was selected basing on the equation proposed by Dillman (2000) which came to be 87. To get responses, random sampling was adopted and questionnaire was distributed by hand, online, visiting ongoing construction sites and companies involved in civil engineering works in Pakistan. A total of 92 valid responses were analyzed.

Various statistical tests were performed on the gathered data to make necessary inferences. Results demonstrate that 54% lean practices are followed with a population mean as $52.7\% \leq \mu \leq 55.6\%$ in the construction industry. Nonetheless, results indicated that lean practices are very important with mean ranging from $81.3\% \leq \mu \leq 86.1\%$. The partial fulfillment and high importance levels given to the lean construction indicates that the construction industry possesses moderate potential (44.4%) and is recognizing the competitive advantages that lean construction practices can offer. The results indicated that awareness, training and commitment from top management are most important factors which are

particularly needed for successful implementation of the lean construction philosophy. The study emphasized the role of educational institutions, Pakistan Engineering Council (PEC), and government entities in promoting the lean construction concept in Pakistan. Adoption of lean construction practices by an efficient management can enable the industry to remove abundance of wastes inherited in the construction process and would ensure delivery of quality projects at reduced cost and time.

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Chapter 1

INTRODUCTION

The manufacturing industry has practiced considerable technological and management changes after Second World War (Womack and Jones, 1996). Whereas in contrast, the construction industry considered to be "backward" and static as compared to the manufacturing industry (Bulent A, 2007). It was in nineties that these criticisms finally guided the construction industry to formulate such philosophies, techniques and methodologies which resulted into changes that would bring construction industry to cope up the pace with manufacturing industry (Koskela, 1992)

As per Koskela (1992), the major problems in construction industry seem to be that it contains abundant of such practices which are wasteful and at the same time struggling to satisfy the customers/parties in participation. The importance of construction is also such that any shortcomings in it will create a huge detrimental effect to the society. The people who are closely linked to construction industry set their eyes to manufacturing industry for uprooting these shortcomings.

Lean production is the biggest revolution in manufacturing industry rooted through car manufacturing industry. After the Second World War, contributions of the lean production resulted into better competitiveness of car manufacturing industry of the Japanese in comparison to their Western counterparts (Ohno, 1988). The effectiveness of lean production can be visualized considering the fact that many manufacturing firms nowadays rapidly transforming themselves by incorporating the methodologies/tools of lean manufacturing into it. "Lean" mainly focuses on minimizing the wastes and endeavors to maintain continuous flow. Application of lean production in construction has critically taken the consideration of several researchers in construction industry specifically in 1990s. The researchers, who worked in this aspect, gave the term "lean construction" after referring to the lean production (Koskela 1992). Lean construction continuously revolves around the basic principles of lean manufacturing. The researchers only need to find out the basic differences in manufacturing and construction industry so as to apply only relevant principles of lean production which are most pertinent for the construction industry. Most of the study in this regard was carried out by Ballard and Howell, (2003). At the moment different

tentacles in the form of an institute and a group have been established and dedicated completely for lean construction improvements and research. This philosophy is rapidly emerging and its practices are being incorporating into the construction world.

In Pakistan, the author hardly found any research or article in lean construction. With the help of this research, the author endeavors to find the lean construction conformance, potentials, competitive advantages it offers and recommend implementing strategies for lean construction in Pakistan.

1.1 Objectives of the Study

The objectives are:-

a. To study change dynamics, lean production and lean construction.
b. To analyze and present the existing lean characteristics of the construction companies in Pakistan.
c. To present results related to potentials and competitiveness of lean construction in Pakistan
d. To formulate strategies for implementing lean construction in the construction industry in Pakistan.
e. To present recommendations for future research opportunities for lean construction in Pakistan

1.2 Research Significance

In the modern era, the success and failure of a company largely depends upon the quickly adoption of the new techniques and flexibility to meet the changed objectives rapidly. Unfortunately, the developments in construction industry by duly incorporating the modern construction management techniques as well as research in this field are lacking. This thesis will provide awareness among the construction industry regarding a well known and very effective philosophy of construction management that is lean construction. The potentials for adopting this philosophy along with strategies of implementation will provide a path forward toward the recognition of lean construction that might lead towards the increased effectiveness of the construction industry. The thesis will also provide the lean practices which are already in practice as well as neglected practices which might be useful in assessing the company's present status toward lean construction and which areas to be looked

upon for completely implementing the lean philosophy and getting the competitive advantages over their rivals. This endeavor will certainly stimulate the development process of altering the mindset of all stakeholders to implement lean construction for better productivity.

1.3 Scope and Limitation

The scope is limited to construction industry of Pakistan and mainly covers the perception of key stakeholders i.e. clients, consultants and contractors/subcontractors about current lean practices as well as the importance of the lean construction practices. An effort has been made to include the inputs from as many as civil engineers who are practically working on diverse construction projects and in respective organizations/firms. An endeavor is made to collect the data through out Pakistan while visiting the projects in Punjab Province.

There are few limitations on this thesis. First of all, the questionnaire is organized and prepared for the persons at management level with adequate experience and education in project management. As at this stage only these persons can understand the terminologies and basic concepts. Secondly the projects were visited only in the cities of Islamabad, Rawalpindi, Sargodha, Gujranwala, Lahore, Kharian and Multan. This is because of the ease in the coordination and availability. Thirdly, the questionnaire was mainly focused on internal operational aspects of organizations/firms which lead to the productivity and implementation instead of design and environmental factors.

1.4 Gist of the Thesis

This thesis comprises of six chapters:

Chapter 1 – Introduction: It contains the introduction of the study with purpose, research methodology and significance.

Chapter 2 – Literature Review: It contains the study of change dynamics and change efforts in the construction industry. Lean production in general and lean construction in particular is discussed progressively.

Chapter 3 – Research Methodology: In this chapter, complete research methodology along with development of questionnaire with sample selection is presented.

Chapter 4 – Data Analysis and results: This chapter contains the detailed analysis of data by using various statistical tools. The results are also presented and explained in this chapter.

Chapter 5 – Potential, competitiveness and implementing strategies for Lean Construction in Pakistan: Inferences are made and potential/competitiveness is assessed for lean construction in Pakistan. Based on the results, necessary implementing strategies are presented.

Chapter 6 – Conclusions and Recommendations: This chapter contains the recommendations for implementing lean construction for general construction industry as well as specific to the organizations in Pakistan. Recommendations for future research are also presented in this chapter. The study is finally concluded in the end.

Chapter 2

LITERATURE REVIEW

2.1 General Change

In quickly varying atmosphere of today and in the stress of international rivalry, firms confer whether their inherent organizational reactions are anticipatedly quicker as compared to the external revolutions and how to keep up sound organizational revolution to cope up with the change. Bruck, Maier and Gerber (2005) emphasized that firms are forced to keep them updated because of surrounding irregularities and uncertainty.

Alberts, (2011) states the importance of the agilty and flexibility in the management style by stating that agility and change management is the key for all the organization in maintaining their worth in the highly competitive enviroments in future. According to him, the need of agilty is due to the uncertainties and complexities in the buisiness world. Alberts, (2011) defines agility as the ability to successfully effect, cope with, and/or exploit changes in circumstances.

Moscoso & Lago Esteban, (2012) state that while costs will remain an important supply-chain objective in the years to come; companies need to balance those cost concerns with greater flexibility and responsiveness. One of the key success factors of supply-chain management is flexibility, which the authors map in a 2x2 matrix of objectives: on the temporal axis, they differentiate between agility and adaptability, and on the object axis, between product and process flexibility. According to Moscoso & Lago Esteban, (2012): "*agility* is the capability to respond quickly to sudden changes in demand or supply or any other type of supply-chain requirement or disruption and a*daptability* is the capability to adjust the supply chain to longer-term changes and requirements, whether structural shifts in the markets, products or technology.

2.2 The Need for Change in Construction

Rapid advancement and effective changes in other industries also affected construction. The improvement in superior materials, employment of mechanical apparatus, advancements of telecomm technologies, quality and productivity terseness contributed a lot in making the changes in the construction industry (Crowley, 1998). Moreover the management changes in

the other industries which resulted into increased effectiveness also demands the changes in the management of construction projects.

2.3 The Early Change Efforts in Construction

Early in the 20th century, architects such as Buckminster Fuller convinced in the use of machineries and fully industrializing the construction. The houses were particularly considered in this regard and efforts were put into to construct them in factories (Gann, 1996). The key intention for this effort was to take advantages from effective management control throughout construction and technological potentials to expand and systematize principal equipment. To industrialize construction, principles that are standardization, pre-fabrication and system building should be present (Crowley, 1998). In order to achieve the standardization, the components of construction have to be pre-fabricated in factories. The amalgamation of these two efforts show the way to system building. These efforts were employed even by the Toyota Company and they tried to construct houses in Japan in the late 1970s but were able to achieve little or no significant reduction in cost, improvement in productivity and demands were even not achieved by this approach.

2.4 Certain Features of Pakistan Construction Industry

Pakistan construction industry is regarded as one of the main industry that leads to some development of the country. Construction participates to increase the GDP and comprises about 14% of employment of total labor force (Labor Force Survey Report-Government of Pakistan, 2005-06). Farooqui et al., (2008) states that

"The industry is more labor intensive, with moderately less use of mechanization. Therefore, compared with other industries in Pakistan (like the manufacturing industry) this industry is labeled as being backward because of its relative lack of use of the latest advances in technology, management styles and procedures. Indeed it invests very meager amounts in research and development, which hinders the industry's ability to adopt new technology and processes. Considering that quality is the most significant factor, the industry is creating a healthy atmosphere to work in and also the involvement of the foreign parties, agencies and funds, the industry is demanding so because of increasing numbers of construction projects."

2.4.1 Problems in Pakistan Construction Industry and Need for Change

Like many other developing countries, Pakistan is also facing critical project management related issues among which cost overrun, time delays and even quality issues are quite prominent. There are several factors that are responsible for these cost overruns indicated by Nida Azhar (2008, ICCIDC–I):

a. Fluctuation in prices of raw materials
b. Unstable cost of manufactured materials
c. High cost of machineries
d. Lowest bidding procurement
e. Poor project (site) management/ Poor cost control
f. Long period between design and time of bidding/procurement
g. Wrong method of cost estimation
h. Additional works
i. Improper planning
j. Inappropriate government policies

The top ten (10) most critical causes of delays in Pakistan construction industry as numerated by Dr. Sarosh H. Lodi and Rizwan Ul. Farooqui (2009) are shown below:

a. Change orders
b. Labor productivity issues
c. Poor site management and supervision
d. Inspections/ Audits
e. Poor cost estimation & control
f. Inadequate project scheduling
g. Defective design
h. Inefficient construction methods
i. Delayed payments
j. Incomplete construction drawings

The ranking of responsibilities of the stakeholders as per a/m report is as under:

a. Contractor = 48.75%
b. Consultant = 17.5%

c. Owner = 16.25%
d. Government = 8.75%
e. Shared = 8.75%.

Developing country like Pakistan has yet to respond to recent changes in construction management and technological improvements.

2.4.2 Development towards Change

Compared to the past, the current decade is witnessing massive infrastructure growth in Pakistan. There are numerous infrastructure development projects in progress as well as under planning. The construction of underpasses and flyovers in comparatively minimum time increased the level of competition among the contractors. Now the traditional old/large firms are trying to meet the challenges as set by the contractors who completed the projects in times of less than 6 months. The awareness of compressing and benefits of completing the projects well before time is coming in the minds of construction industry stakeholders in Pakistan but the problem is whether the companies are thinking of compressing the time only or minimizing the time by duly considering the aspects of cost and quality. But good thing is; now the stakeholders have a bit tilted their thoughts toward achieving the best to stay alive in the competition.

2.5 Lean Thinking and Lean Production

Lean thinking takes its inspiration from the Toyota Production System (T. P. S.). The initiators and advertisers of lean production are Toyota's chief engineer Taichii Ohno and the C. E. O. Eiji Toyoda. They made an endeavor for eradicating both veiled and apparent wastes. The method displayed enormous considerations soon after the competitive advantage gained by the Toyota company over its American and local competitors. International Motor Vehicle Program (I. M. V. P.) basically pioneered the name "lean" and introduced it to the rest of the world (Womack, Jones and Roos, 1991). They compared the mass/existing system with production system developed by the Toyota Production System. They called Toyota's production system as "lean production", referring to diminishing inventories, being flexible and minimizing waste. Lean manufacturing main concepts are (Ohno, 1998):

a. Production is pull driven

b. Elimination of all non-value adding events to reduce/minimizing wastes
c. Identification of the defects at the outset so that the things are done right at the very first time
d. Continuous improvement (Kaizen)
e. Formulation of very strong and long-term relations with suppliers
f. Capable of producing variety of goods and in various quantities
g. Team work

2.5.1 Just – in –Time Production

Just in Time management is not a technique or even a set of techniques of manufacturing, but is an overall approach or philosophy which embraces both old and new techniques. According to Voss(1987), a comprehensive definition of JIT is more simple and that is " An approach that ensures that the right quantities are purchased and made at the right time and quantity and there is no waste. It tries to incorporate zero inventories, world class manufacturing and continuous improvement. Benefits of J.I.T as dictated by Suzaki (1986) and Wheathey (1992) are the followings:

a. Elimination of waste
b. Reduction of buffer stocks
c. Continues improvement
d. Increased flexibility
e. Increased quality
f. Increased productivity
g. Less space requirement
h. Lower overheads
i. Pull/Push System

2.5.2 The Kanban System

In lean production system, production is pulled upstream whereas in traditional mass production, production is pushed from upstream to downstream. As per this system, materials will not be processed till the time demand from the downstream arises. This system is called "kanban". Japanese gave the name "Kanban" for cards or signals. It is invisible conveyor and is the mean by which customer (scheduling operation) instructs a

supplier (preceding operation) to send more material. The concept of Kanban system can be easily understood from the Figure 2.1:

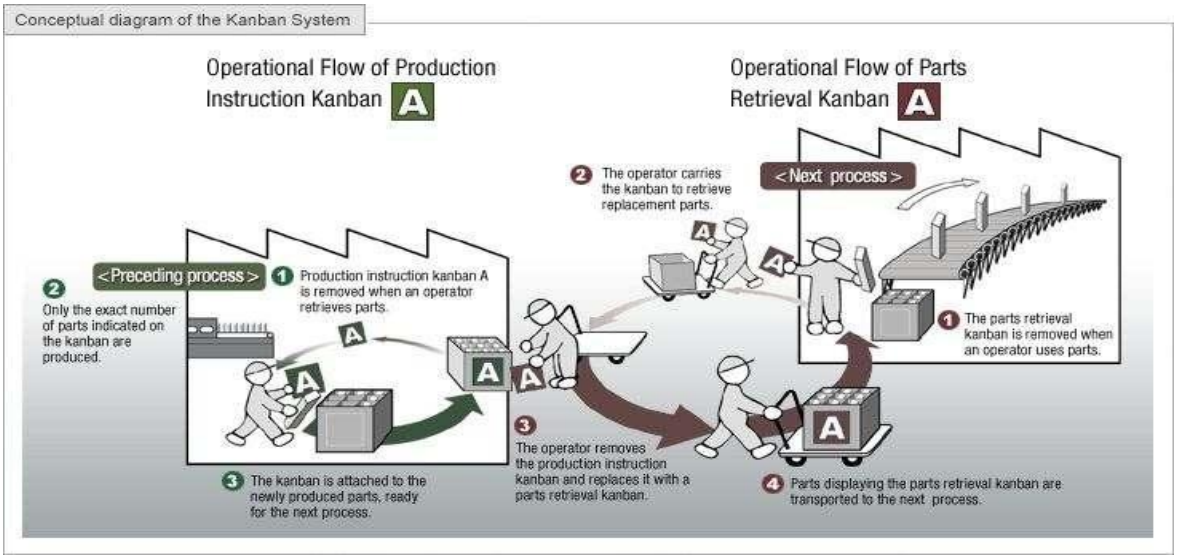

Figure 2.1: A Kanban System

(Source: Toyota Motor Company, 2007a)

The rules of Kanban system as dictated by Halevi in 2001are:

a. Preceding process, manufactures selected item in the quantity and sequence dictated by the kanban.
b. Succeeding process chooses and select items in quantity pointed out on the kanban in the preceding process.
c. Items are neither manufactured nor transported, without the use of a kanban.
d. Kanban is always attached to the goods.
e. All types of defective products are retained at the earlier outset and not delivered to the succeeding process.

2.6 Lean Construction

The philosophy as elaborated by the lean production and followed in manufacturing industry also received theconsideration by construction industry's persons as well. Particularly in the start of 1990s, major developments in this discipline started taking place. Louri Koskela, considered as the pioneers of lean movement in construction, had the honor of hosting the first conference of the I. G. C. L (International Group for Lean Construction) in Finland in

1993. It was in this conference that group of researchers agreed to the name “lean construction”.

2.7 Concepts in Lean Construction

As lean construction is inspired from lean production therefore the purpose of the lean construction efforts was first to identify and apply the relevant lean methodologies and principles to the construction. However the exact copying of the lean applications of the manufacturing straight to construction is neither feasible nor required because of the differences in both the industries. However Koskela (2000) highlighted that, though the manufacturing and construction industries are different but the fact that the ultimate aims of the production which are minimizing wastes, maximizing value and achieving the best quality are almost the same, He basically elaborated the framework and identified the relevant principles of production system which can be applied to the construction.

The perception of both the industries as production units in which semi completed works are handed over to the next process with the application of both machinery and crew seems to be analogous. The goal is taking the basic lean motives such as elimination of waste, cycle time reduction, variability reduction, pull – driven production control, continuous flow and continuous improvement as pivotal points in the context of construction. Therefore, it can be said that lean construction standards emerged from lean production can be divided into roughly eleven parts:

a. Literature and theory
b. Managing and developing design and Product respectively
c. Cost management and commercialism
d. Designing complete production system
e. Prefabrication, repetitiveness
f. Supply chain management
g. Integration of information technology with lean construction
h. Planning and Controlling Production
i. Safety
j. quality and environment
k. Cultural changes and people involvement
l. Use of performance measuring techniques

Abdelhamid defines lean construction (Abdelhamid, "Lean Construction") as: "A holistic facility design and delivery philosophy with an overarching aim of maximizing value to all stakeholders through systematic, synergistic, and continuous improvements in the contractual arrangements, the product design, the construction process design and methods selection, the supply chain, and the workflow reliability of site operations."

The crux of the above mentioned definition is that lean construction formulates new production management philosophy which directly challenges the tradeoff between quality, cost and time. Until now, companies all over the world are employing two delivery channels for the application of Lean construction. One of them is a new project delivery system called the Lean Project Delivery System (L. P. D. S.) which is developed by Lean construction Institute. Second one is Last Planner Production Control which is developed by Howard and Ballard's. Lean construction has been extensively utilized in countries like U.S.A, U.K, Brazil, Peru, Singapore, Korea, Australia, Finland, Denmark, Venezuela, Chile, Ecuador and also taking its roots in few African countries.

2.7.1 T. F. V termed as Transformation-Flow-Value

Koskela (1992) elaborated that in construction, the complete work is converted into smaller activities as conversion activities which are not dependant on one another. Preceding activities have to be completed in some form for the start of succeeding activities. For efficient delivery of the complete project, improvements can be achieved by simply improving these smaller activities which are basically the conversion activities. This type of thinking in construction takes the form of conventional/existing practices in construction management. Whereas the lean construction takes the understanding of interconnections and "flow" among activities in addition to the conversion. It was the Koskela (1992) who suggested both a conversion and a flow approach to construction.

Talking from the pure conventional construction management concept, all conversion activities are value adding activities but the generation of wastes takes it root from the flow in between these conversion activities. Hence the flow has to be studied in detail for recognizing the wastes and tackling them. This is one of the basics of the lean construction principles.

Koskela (2000) summarized the basic differences between T.F.V management approaches in Table 2.1 below:

Table 2.1: Comparison between T. F. V

	Transformation	**Flow**	**Value generation**
Conceptualization	Inputs are transformed into outputs	Material flow after transformation, waiting, inspecting, moving	Customer's value is formed through fulfillments of his requirements
Principle	Realization of the production efficently	Waste Elimination i-e recognizing non value adding activities	Achieve value for supreme probable value
Related Principle	Conversion of the production tasks, Minimize cost of each production task	Squeeze lead time, Lessen variability and moving toward simplification, increase transparency, increase flexibility	Ensure that all requirements gets captured, Ensure flow down of customers requirement, Measure value
Methods and Practices	Work and organizational breakdown structures	Continuous flow, Pull production flow, Continuous improvement	Methods for requirement capture, Quality function deployment

(Source: Koskela, 2000)

Table 2.1: Comparison between T. F. V - Continued

	Transformation	**Flow**	**Value generation**
Practical contribution	Taking care of what has to be done	Taking care of what is unnecessary is done as little as possible	Taking care that customers requirements are met in the best possible manner
Suggested name for practical application of the view	Task management	Flow management	Value management

(Source: Koskela, 2000)

Lean construction inventiveness is the one which proposes a framework in which understanding and appliance of transformation, flow and value management are combined as compared to only focusing on the conversion based approach.

2.7.1.1 Non – Value Adding Activities

Wastes are basically identified as; avoidable and unavoidable wastes by Formoso Isatto and Hirota (1999). In case of unavoidable wastes, benefits of eliminating the wastes are lesser as compared to the investment to eliminate the waste. Whereas there is vice versa in avoidable waste in which the benefits of eliminating are more than the investment to reduce it. In the same way, non- value adding activities are also characterized by two groups; essential and not essential non-value adding activities. There are certain activities performed on the construction projects which are essential but giving no value to the product, example is, examining projects on-site. But activities like waiting for machineries required for the activity completion are non essential non-value adding activities. The main logic of reducing non value activities is decreasing the lead time. Figure 2.2 shows the effect of reducing the wastes that are non value adding activities on the cycle time flow:

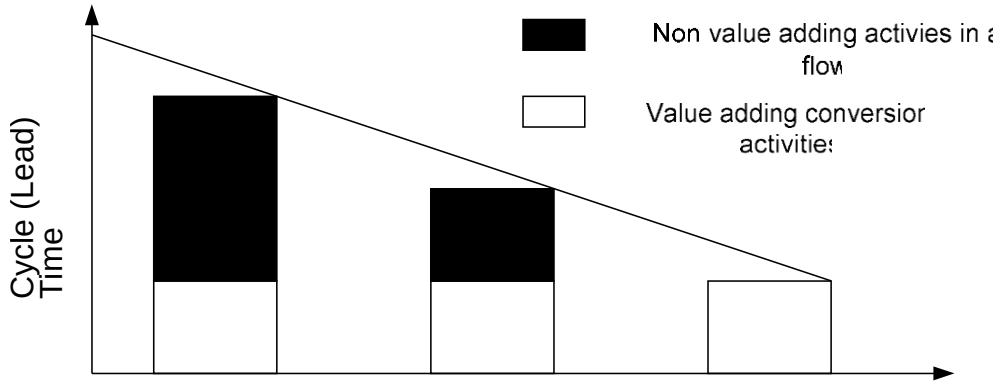

Figure 2.2: Effect of Waste Reduction on Cycle Time

(Source: Koskela, 1992)

Ohno (1998) emphasized the need of immediate elimination of the unnecessary non-value adding activities as doing so will provide numerous improvement opportunities. However emphasis should be given in reducing the time of all the essential non-value adding activities which can be effectively done by employing the tools and techniques of lean.

2.7.1.2 Variability

Variability can only be well understood if concept of recognition of flow is in the mind. It is the standard deviation of the rate of progress of an activity. Koskela (2000) identified that variability should be kept at its minimum for both the process time and flow. Process time variability is the variability of processing on the workstation for activities completion. In easier words to say that how activities are performed. On the other hand flow variability is the variability in between succeeding and preceding activities.

According to Koskela (1992), variability both in process time and flow basically increases activity cycle times and lessens efficiency because of increased waste. This concept actually describes the importance of standardization in productivity, work flow reliability and simplification.

2.7.1.3 Simplification

Simplification in lean perspective means to abolish certain components in a production system. Simplification is an important part in lean. As it makes the production unit more reliable as complexity causes uncertainty. Eliminating non-value adding activities will have direct contribution in simplification of a production system.

2.7.1.4 Transparency

Through transparency, the parties involved will have a better recognition of current situations in the production unit. They will come to know the desired goals, value and expectations required out of them. With transparency, both the simplification in the flow of information and support in making the people to feel more responsibility is achieved that helps in developing the skills of taking initiatives.

2.8 Construction Waste

Material waste as explained by Garas, Anis and Gammal (2001) in construction occurs because of:

a. Excessive ordering than required
b. More production than required
c. Incorrect handling of materials
d. Inappropriate storage
e. Defective manufacturing
f. Theft or damage

Whereas time waste occurs (Garas, Anis and Gammal, 2001) because of:

a. Waiting
b. Work stoppages
c. Elucidation
d. Deviations from given information
e. Again doing the work (Rework)
f. Non conformed work (errors)
g. Conflicts between various specialties
h. Unnecessary delays in planning activities
i. Unnecessary wear and tear of equipment

Koskela (1993), stated that from 6 to 10% of the total cost of constructions in the U.S and Sweden had been waste. Another aspect of waste in terms of workers timings are as stated by Horman and Kenley (2005), after analyzing workers productivity on 26 works. At an average 49.6 percent of the total working timings are the wastes with a standard deviation of

11.9 percent. Zhao and Chua (2003), after performing an analysis on 8 projects of various categories stated that the most man-hour consuming wastes are:

a. Workers hindrance
b. Unnecessary inspections
c. Equipment used by other crew
d. Waiting because of the installation of equipments
e. Waiting for orders and instructions
f. Working again because of sudden design change
g. Stockpile problem
h. Material dealer not supplying the material at right time

2.9 Construction Waste in Pakistan

Unfortunately there is hardly any study available regarding amount of waste in construction industry of Pakistan. In Pakistan, the construction wastes are in abundance. But the dilemma is that, the contractor community has still not realized the fact that large scale wastages exit in their working style. In order to improve, one should realize the problem but the problem is that the construction contractors are not realizing the shortfalls. They have only frozen their eyes on a set profit margin which they get because of the standard rate analysis in the government departments. Strangely the same is applied in the private sector. If 10 percent waste is predicted through so many research work in developed countries where management is quite efficient, technology is at its prime and where cultural issues are not that much backward, just imagine the amount of waste in construction industry of Pakistan where the cultural as well as management is not up to that level and technological advancement is so behind. However during the survey especially in interviews, this question is often asked in addition to the actual research based question. The main reasons are:-

Material waste because of:

a. Material not following the specifications described in the contract
b. Storing abundance of material with the justification of price hikes
c. Lower quality of material supplied by the supplier
d. Customer's changing requirement on arrival of material
e. Material wastage during shifting and weather effects

f. Planning flaws
g. Mistakes carried out by the workers

Time waste due to:

a. Delay in the supply and availability of the material
b. Replacing the materials that do not match the design specifications and waiting for its arrival
c. Design changes, non-availability of design
d. Workers mistakes
e. Weather conditions
f. Imperfect planning
g. Irregular cash flow.

2.10 Integration of Works (Work Structuring)

Ballard (1999) states that in work structuring one has to reply the following questions:

a. What quantity of work that will be given to from one group to another?
b. What will be the sequence of work quantities through the work force?
c. Whether buffers are required against variations in quality, material availability, design changes and producing quantity? What will the size of these buffers?
d. Time to execute different nature of works?

2.11 The Last Planner System

Last planner can be considered as the most reliable and concrete invention of the lean construction which is basically used for production control and maintaining work flow (Ballard, 2000b). It was introduced by Glenn Ballard and Gregory Howell in 1997. It's main metric is Percent Plan Complete (P. P. C.).

The Last Planner converts "should be done" activities, that emerges from the master schedule, in "can be done" (Ballard, 2000b). Difference between "Can be done" and "should be done" is only the existence of constraints in the "Can be done". It is here from "can be done" activities, that "will be done" activities are formulated for daily or weekly plans. Now once the works are executed then during and after work "did" activities are compared with the "will be done" activities, by Percent Progress. Control (P.P.C). The

person, who finally assures and believes that the work now is ready to be executed, is the Last Planner. Figure 2.3 shows the basic idea behind the Last Planner System.

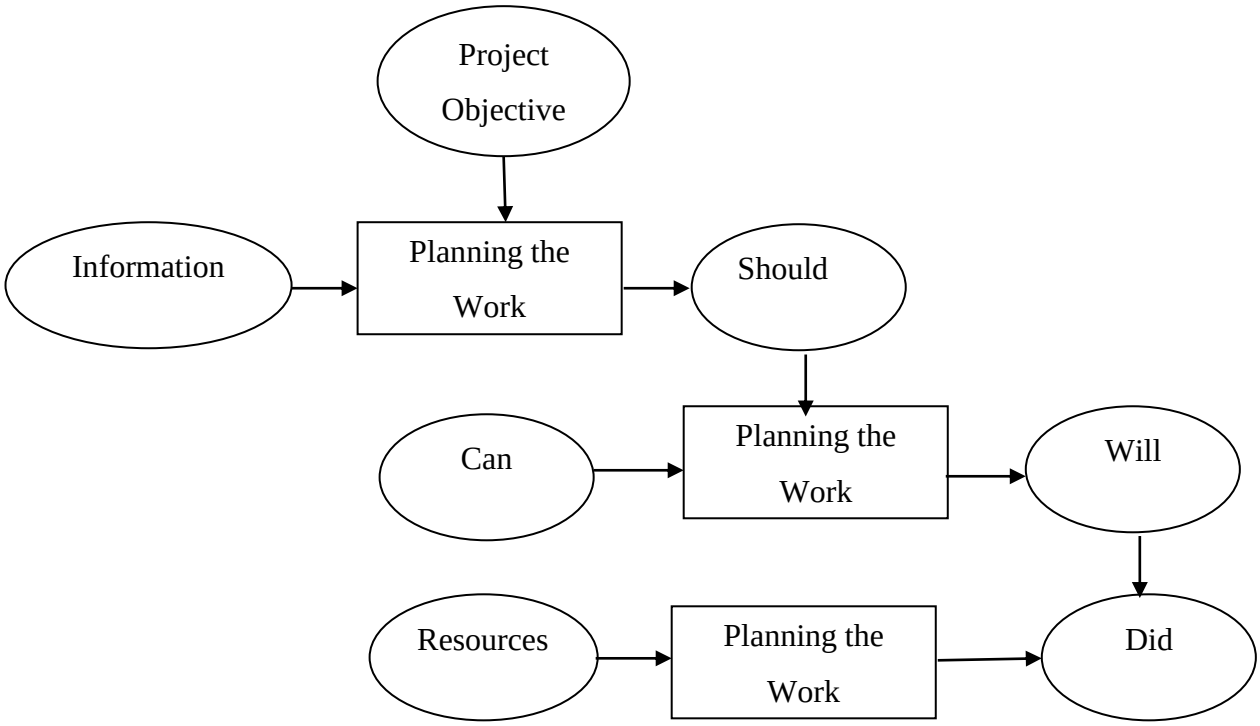

Figure 2.3: The Last Planner System

(Source: Ballard, 2000b)

The first important step is the determination of Master and phase schedules (should be done activities) which are totally extracted from design criteria and work structuring process.

The second important step is determination of lookahead plans (Can be done), basically derived from Master and Phase schedules by duly incorporating the constraint. This plan is generally prepared for 4 to 12 weeks by duly incorporating the constraints. Durations are recalculated depending upon the conditions hampering or favoring them.

Next planning level after the "Can be done" assignments as formulated during lookahead plans, takes into account the interconnections with other production units. Here all the stakeholders with in a production unit including the upstream and downstream personals settle on workable backlog. It includes a more "pull" planning practice. Availability of resources, materials and the demand are also considered. From this practicable backlog, a last planner composes weekly work plan, by duly taking into account the applicability of the

chosen assignments. This final work plan will give the last planner a "will be done assignments".

During the execution of work assignments after the formulation of "Will be done" assignments, the "did" assignments will be measured against the "will be done" assignments at the end of each week called as Percent Progress Complete. If the value of P.P.C is smaller then the indication of poor production management is evident. At this stage complete investigation is carried out to determine the causes of low P.P.C values. Once causes are identified, remedial actions are taken to improve the P.P.C. By this way a concept of learning and thinking will be established with in the organization.

2.12 Methodologies/Tools in Lean Construction

Paez et al. (2005) numerated certain functional tools for applying lean in construction by defining levels as given below and also enlisted in Table 2.2:

Level One: Lean manufacturing techniques to be directly applied as it

Level Two: Lean manufacturing techniques are modified accordingly

Level Three: Only specific to construction techniques.

Table 2.2: Classification of Methodologies/Tools

Levels	**Technique for Lean Construction**
Level 1	Material Kanban Cards
Level 2	Visual Inspection Quality Management Tools Concurrent Engineering Defect identifying and removal techniques by 5 Y's
Level 3	Last Planner Plan Conditions of Work Environment Daily Meetings

(Source: Paez et al., 2005)

Although all these techniques can be employed separately but the construction leanness of the firms will be fully displayed and lean construction benefits can only be fully utilized if all the above techniques be employed in conjunction with each other.

2.12.1 Use of Material Kanban Cards in Lean Construction

Material kanban cards and kanban system of lean manufacturing have the similar functions. It means to provide necessary materials required for the construction, just-in-time so that materials are available at the right time. If the materials are not available when required then flow at construction site will be seriously disturbed. It aims at minimum storage, reducing inventory and promoting pull-driven production. The system includes market locations of material, at site stores (satellite), internal and external constant routes vehicles, supplier kanbans and an inventory management system. From supplier to market places the material is supplied in external vehicles and from market places to satellite stores in internal vehicles. These internal and external vehicles are called milk run vehicles (predefined routes). Some

uniform bins are used as kanban cards to pull the materials from suppliers. Coordination between market and satellite stores are carried out either verbally or in writing.

2.12.2 Increased Visualization

It focuses on improving the transparency in construction. One way of doing this is by giving the employees opportunities to identify the milestone and the present status of a project by the use of some visual gadgetry like boards etc.

2.12.3 Daily Huddle Meetings

To increase the involvement of employees, daily huddle meetings are planned regularly with the employees by the top or middle management. Employees contribute their past experience for the present scenario and any future comments about the upcoming tasks. People generally plan their own tasks and see it in the broader sense by duly interacting with other people involved in their projects.

2.12.4 First Run Studies

It is often referred as the P. D. A. C (Plan, Do, Act, Check) cycle (Salem et al., 2005). It is a tool that can be used to continuously improving those critical activities in which there exists a high variability and that are time consuming or has high cost in a construction project. As per this study, the identification of such activities and then completely understanding them by using all available methods like photographs, videos, charts etc.

2.12.5 Fail Safe for Quality

This approach means heavy focus on the quality and safety in the construction project. Actually this technique takes quality as something which can be controlled before execution and results. Saurin et al. (2002) suggested a detailed safety framework to be incorporated in the construction. As per this, the safety is integrated in long term and look ahead planning.

2.12.6 Concurrent Engineering

It aims at executing disciplinary effort in which the design and construction teams work in parallel. As per Paez et al. (2005), its main aim is to develop and execute diver tasks in parallel to each other by employing multidisciplinary teams in order to achieve best quality, productivity and functionality

A part from executing their respective tasks it aims at working with extensive communication and sharing information among themselves as well as the customer. It evaluates some severe risk analysis and allocating the resource allocations under the severe constraints of time. The designed products and the construction/production system will be a free flowing and produce the best results under concurrent engineering.

2.12.7 Five S's

The Five S's (5S) are few rules for housekeeping and organizing the place of work so that efficiency is increased and wastes associated with workplace is reduced. The main aim of the Five S's is to make people proud of the environment in which they work. It is a proven fact that if people are conceited and feels pride of their workplace they can produce enhanced quality in an easier way. The Detail of five S's is as follows (U.S. Environmental Protection Agency, 2006a):

a. Sort – Sort those things which are immediately and frequently required from those things which are less important and not necessary things. The immediate and frequently used items to be placed as close to the site as possible. Always try to abolish unnecessary items.
b. Set in order – The important items are organized in a way that these are readily accessible so that all types of wastes, due to worker's motion, be reduced.
c. Shine – To increase the level of satisfaction and pride among workers as well as to reduce the waste as a result of uncleanness, it is necessary to clean the work place and machinery.
d. Standardize – Set a side clear procedures to standardize the first 3 S's throughout the work.
e. Sustain – Effort should be made in integrating all the five S in the daily culture by training, awards and control. With this, the sustainability of 5'S will be achieved in longer run.

2.12.8 Five Why's

Five why's is very effective tool for finding the root cause of a problem or defect. It works by asking five questions consecutively in response to the answers of the previous questions. It is more or less similar to the fish bone diagram used for finding the root cause of a problem

2.13 Difference between Conventional Construction and Lean Construction

Kim (2002) summarized the major deviations of lean construction from the traditional construction. The summary is presented in Table 2.3:

Table 2.3: A Brief Comparison between Conventional Construction and Lean Construction

Lean Construction	Conventional Construction
Control	
Causing events to confirm to plan	Monitoring against schedule and budget
Optimization	
Entire Project	A specific activity
Scheduling View Points	
PULL Work schedule based on when its completion required by the successor activity	PUSH Work schedule based on emphasizing required start dates for activities
Planning	
Learning	Knowing
Coordination	
Keeping a Promise	Follow the orders
Goal of Supervision	
Reduce variation and manage flow	Point speed and productivity
Production System	
Flow production system	Conversion production system

Source: Kim, 2002)

Table 2.3: A Brief Comparison between Conventional Construction and Lean Construction-Continued

Lean Construction	Conventional Construction
Production Process	
Effectiveness	Efficiency
Performance Measurement	
Percent Plan Complete (P.P.C)	W.B.S., CPM, Earned value
Customer Satisfaction	
Successor process satisfaction	Owner or final consumer satisfaction

(Source: Kim, 2002)

2.14 The Importance of Measuring Lean Conformance

This measurement will give a fair amount of idea regarding whether the firms are all set or have the potential of following the lean construction methodologies and tools or not. It always gives the strengths and weaknesses in the path toward leanness. It is not must for all the firms to follow the lean construction philosophy in true sense depending upon their cultural and benefits they attain through traditional construction because there can not be a single best method for improving the dynamics of the business, in this competitive environment. However it can only be said that the survival of firms in longer run can be best achieved if they enhance their management skills to cope up the competition. Every construction firm has few of the ingredients of lean construction but the difference is in the level of following all the lean characteristics. With measuring existing lean construction practices, standard operating procedures of lean conformance can be developed to an acceptable limit. Measuring lean conformances can serve as a guide line for formulating the lean implementation procedures..

In Pakistan, the author is unable to find any study on lean construction. However considering the peculiar environment of construction industry in Pakistan in which competition among the contractors and consultants are increasing with the construction of enough high rise

buildings, industries, flyovers, underpasses and road networks, the companies are striving for their survival in the industry and in their minds creation of something new is striking but this is at the very initial stage. Author very strongly expects that any pilot project once completed in Pakistan using the tools and techniques of lean construction, the majority especially the medium and large firms will incline toward this concept after realizing its benefits.

Chapter 3

RESEARCH METHODOLOGY

3.1 Method

The dynamic and multi dimensional nature of the lean construction derived from the lean characteristics, it is very difficult to measure the lean conformance in a country. It requires the collection of respective data from the construction industry in Pakistan. In order to get the data, a questionnaire on the line of lean construction principles was developed. The questionnaire comprises of total 95 questions in all. The first 11 questions aim at clarifying respondent's and firm's attributes. Remaining 84 questions are distributed in such a way that through one question, lean conformance practice is measured regarding the respective sub principle whereas next immediate question determines the importance of the same. Hence 42 questions are used to measure the lean conformance practices and rest 42 questions are used to determine the importance of each sub principle. Schematic layout of the research methodology used in this research is given in Figure 3.1. After the preliminary study, detailed literature review is carried out and a number of already developed questionnaires are examined. 5 principles and 16 sub principles are identified using the model proposed by Diekmann et al. (2003). Questions are drafted for each of the sub principle to determine the lean construction practices within the country. The computation of lean conformance and importance level are carried out separately which ultimately lead to the potential. The potential in numerical form is calculated by multiplying the lean conformance percent fulfillment with importance level in percent.

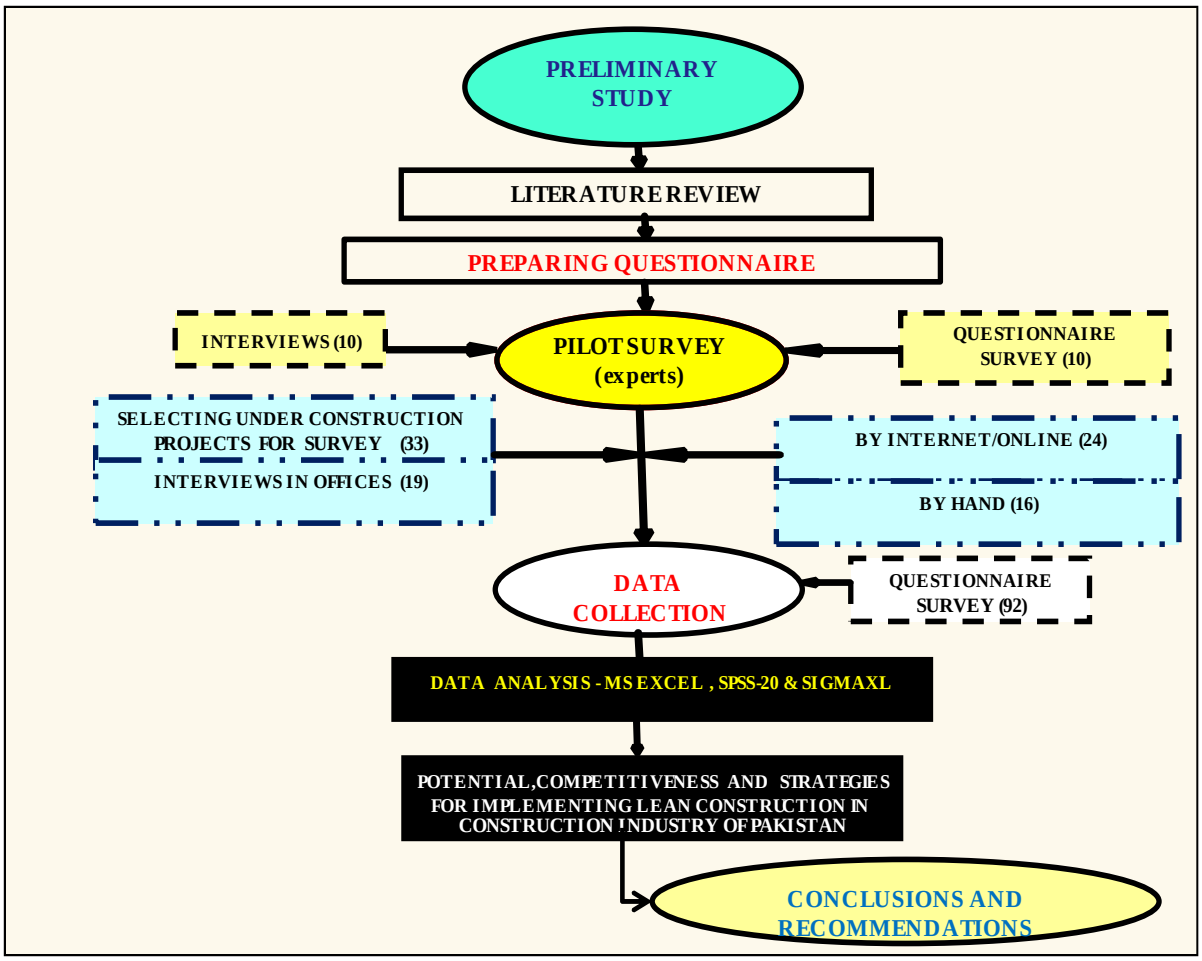

Figure 3.1: Research Methodology

3.2 Questionnaire Design

The model developed by Diekmann et al. (2003) is taken as a guide line for measuring the lean conformance. This model was formulated by the research team under the umbrella of Construction Industry Institute. An elaboration of the model is given below with principles at first level and sub principles at second level, Figure 3.2:-

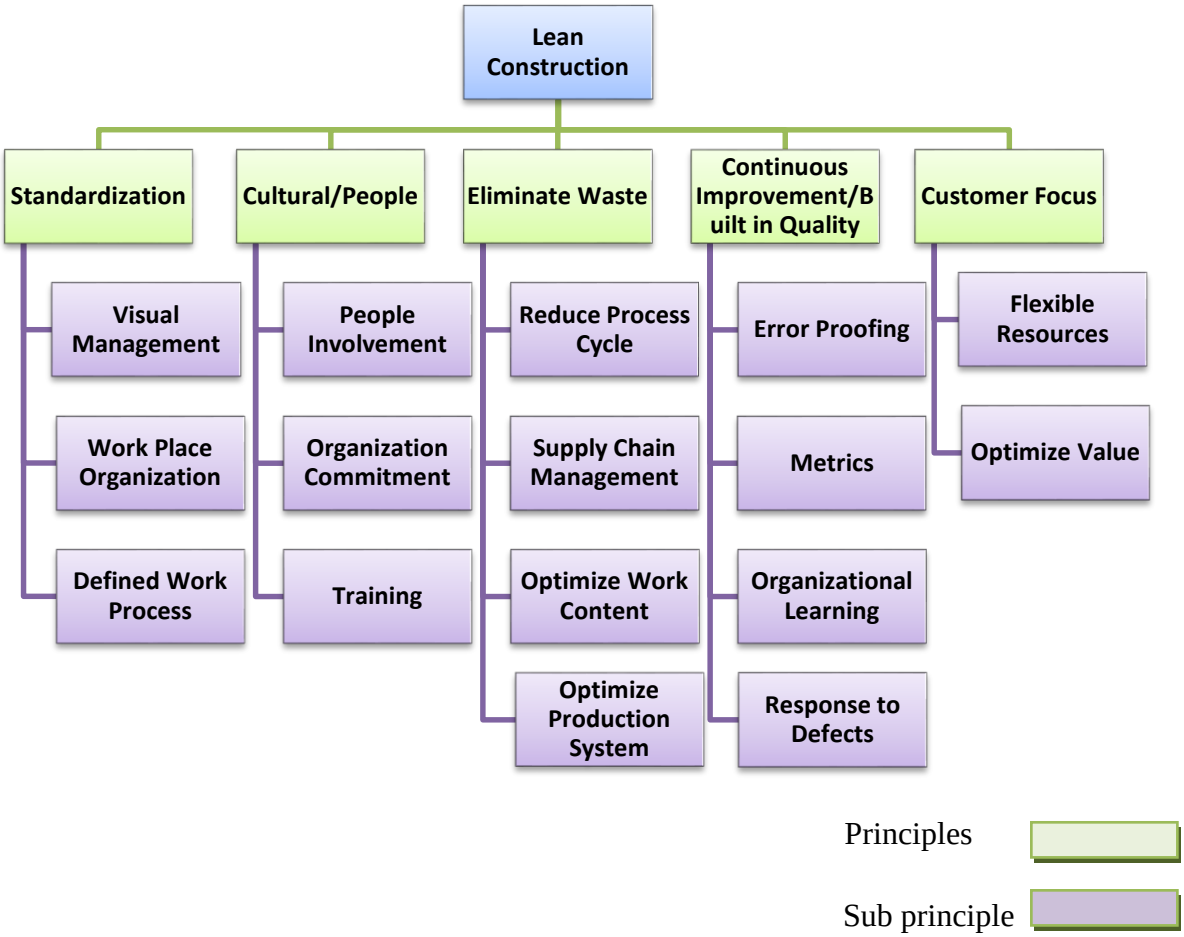

Figure 3.2: Lean construction Model

(Source: Diekmann et al., 2003)

Brief description of the model is given in Appendix I. As per the model, the lean construction has 5 main principles and 16 Sub – principles.

Keeping in view the peculiar Pakistan environment where the education level as well as cultural aspects in construction industry is not as much high as in developed countries, the questions are framed in such a way that these are easy to understand. To check the authenticity of the questionnaire pilot survey was conducted from the experts in the industry before finalizing the questionnaire.

3.2.1 Pilot Survey

Pilot survey was carried out from 10 respondents who are quite educative and experienced in the construction industry. The aim of the pilot survey was to check the authenticity and applicability of the questionnaire so that it fits into the Pakistani environment and easily

understandable. The respondents were selected from the contractor, consultant, clients and academia. Almost all the experts agreed on the questionnaire but the length of the questionnaire was objected by only one expert. As a result, few questions were shortened in statements only to decrease the length and final questionnaire was circulated in the Pakistan construction industry for getting the responses.

3.2.2 Questionnaire

To determine the lean conformance, questions were developed for each principles/sub principle. Generally more than one question, each corresponding to respective sub principle was formulated. However only the sub principle "training" in cultural/people has one question. People involvement, Response to defects, Organization learning, Flexible Resources and Visual Management, contain three questions. The supply chain management optimize production system and reduce process cycle time sub – principles have four corresponding questions. The rest of the sub – principles have two corresponding question.

The respondents were given 6 choices to answer the corresponding questions. The respondents had to evaluate the practices with in their organization while answering the questions. A sample question is presented in Table 3.1:-

Table 3.1: A Sample Question for Lean Conformance

All informations/knowledge techniques/changes are always and timely shared/presented to the concerned department in the organization	Never	Seldom	Sometimes	Often	Almost Always	N/A

As an example, if the firm/organization has never practiced the statement, they will tick NEVER. If they had no idea or thought regarding the statement, they chose the box under N/A. Any firm/organization ticking ALMOST ALWAYS means they follow the lean practices almost all the time. If the response is more towards the cluster of OFTEN – ALMOST ALWAYS, the firms follow leaner practices which mean that they have more potential for acquiring and mastering the practices with in their firm.

To judge the importance of each sub principle with respect to the applicability in the construction industry in Pakistan, a question at the end of every statement was formulated to check the respondent's level of importance for the principles. Sample of the questionnaire is given as below in Table 3.2:-

Table 3.2: A Sample Question for Importance Level

Irrespective of whether you have implemented or not, do you consider that above statement on the left is important in achieving the objectives of project in efficient/best manner	Hardly ever	Sometimes	Most of the times

The respondent if tilted towards MOST OF THE TIMES, indicates that he/she considers the sub principle as important and have the potential to perform but few hurdles with regard to execution prevents him to implement it, if the score of the respondent is low for conformance question just before it.

Online version of the questionnaire was also prepared in Google documents/drive as well a part from the print outs. Following methods were used to get the response:-

a. Distribution by hand
b. Distribution on internet
c. Visits to sites and personnel interviews on site
d. Visit to offices and personnel interviews

The words format of the questionnaire is attached as Appendix II.

3.3 Survey Sample

3.3.1 Sample Selection

The purpose of statistics is to have summary measure about some characteristics of the population through sampling. For good results sampling should be a true representative of population. The sample for this research is selected from a population of civil engineers working in construction organizations/firms in Pakistan. As per the PEC magazine 2013, there are around 32184 registered civil engineers. Assuming that 15 thousand are

unregistered engineers or in process of registration, the total population size can be concluded as approx. 50000. It is fairly a large population and the sample selection will represent various construction experts including clients, consultants and contractors with different categories and backgrounds. For this research, the random sampling technique is adopted by selecting the civil engineers at random all over the Pakistan. However the projects are selected from the Province Punjab especially from the cities of Rawalpindi, Islamabad, Kharian, Sargodha, Lahore and Multan. Total of 33 under construction projects and 19 offices of different organizations/firms are selected for personnel interviews with the key project stakeholders.

The questionnaire was therefore distributed to 232 randomly selected potential respondents, working with different organizations/firms.

3.3.2 Sample Size

Factors which should be taken into account in determining an appropriate sample size are:

a. Sampling error
b. Population size
c. Confidence level

Equation (3-1) gives the formula which can be used to calculate the sample sizes (Dillman, 2000):

$$\mathbf{Ns} = \frac{\mathbf{Np(p)(1-p)}}{\mathbf{(Np-1)(B/C)^2 + (p)(1-p)}} \quad (3\text{-}1)$$

where;

Ns: sample size for the desired level of precision

Np: population size i.e. 50000

P: proportion of the population that is expected to choose one of the responses categories (yes/no); $P = 0.65$

B: acceptable sampling error; (±10% or ±0.10)

C: Z statistic associated with the confidence level (1.96 corresponds to 95% confidence level)

There were 92 valid replies out of 232 showing an overall response rate of 40.5%. In the construction enterprises, a good response rate is around 30% (Black *et al.*, 2000). Therefore, the response rate in this research is acceptable. The sample size is 92 for this survey, however to know whether or not this sample size truly represents the population, Equation 3-1 is used which exhibits sample size required for various population sizes and characteristics.

As per the PEC magazine 2013, there are around 32184 registered civil engineers. Assuming that 15 thousand are unregistered engineers or in process of registration, the total population size can be concluded as approx 50000 (Np). This technique is new and mostly expected that not been followed by the civil engineers/organizations/companies, it means 65 % (p) of the population are expected to give lower values to the answers. Acceptable level of sampling error is taken as 10% and Confidence Interval as 95%. By applying these values in equations (3-1), the sample size comes out to be 87 for a sampling error of ±10%. Analysis of the collected data by SPSS, gave maximum sampling error as ±9.70% which is less than ±10% so any sample over 87 is quite acceptable for a sampling error of ±10%. Hence a sample comprising of 92 respondents is quite reliable for further analysis.

3.4 Reliability and Validity of Survey

The reliability and validity of a study determine that the research instrument fulfills its intended purpose. "*Reliability* refers to the consistency of a measure and to the probability of obtaining similar results if the measure is to be duplicated" (Oppenheim, 1992). Reliability can be measured in various ways however most commonly used method in researches is internal consistency. *"Validity* determines whether the score or question can measure what it is supposed to measure" (Oppenheim, 1992). To ascertain the reliability and validity of a questionnaire, researchers use numerous methods. As such, some will refer to the research instrument used in previous studies already been proven valid and reliable.

3.5 Data Analysis Techniques

MS excel, Sigma XL and SPSS-19 are used to analyze the data. The study follows usual level of significance i.e. $\alpha = 0.05$. Following statistical techniques are used for analysis:

3.5.1 Test for Normality

An evaluation of the data normality is a pre-condition for the use of numerous statistical tests. It is performed to know whether data is normally distributed or not, i.e the data parametric or non-parametric in nature. A more thorough test of normality, suitable for data sets of about two thousands (2000) elements or less is presented by the Shapiro-Wilk test. To count as sufficiently normal, the Significance (Sig.) value should be non significant (i.e. it should be larger than 0.05). For the data set more than 2,000 values, Kolmogorov-Smirnov test, also known as K-S Lilliefors, is more suitable. Anderson Darling test was also performed to check the normality with same characteristics. Hence in this study Shapiro-Wilk test and Anderson Darling test are used to check the normality owing to the limitation of sample size. Incase the data set fails normality, before going to the non parametric; the data is either carefully observed for outliers or error and also the data is transformed by Box Cox Transformation to make it normal. Box Cox transformation use the value of lambda and raises the data set values by taking the power of lambda in the range of -5 to 5 and then determines the best fit power.

3.5.2 Kruskal-Wallis Test and One Way ANOVA

The Kruskal-Wallis test and one-way analysis-of-variance are used to determine whether three or more independent groups are identical or diverse on some variable of interest. It is more appropriate for finding statistical evidence of inconsistency or differences in perception, using mean values. The Kruskal-Wallis test is used for non parametric data whereas one way ANOVA is used for parametric data. Some of the collected data did not pass the normality test so the Kruskal-Wallis test is used for further analysis. It is much less sensitive to outliers. The null hypothesis (Ho) for the test is that the means of variables are equal and is rejected if the result is significant. The results are tested against the hurdle of significance of 0.05. If significance value is more than 0.05 then it means that all the stakeholders have similar perception about the issue and vice versa. Before performing the One way ANOVA, its all assumptions are tested by using the SPSS 20 version to check the applicability of the One

way ANOVA. For two independent groups, Mann Whitney test is performed to check the differences of perceptions.

3.5.3 T Test Statistics

T test statistics is performed for all the normal data to get the inference for the population from the sample mean. After getting the descriptive statistics, the values of sample mean, standard deviation and sample size is put in the following equation to get the population mean at 95 % confidence interval.

$$\overline{X} - t_{\alpha/2,n-1} \bullet \frac{S}{\sqrt{n}} \leq \mu \leq \overline{X} + t_{\alpha/2,n-1} \bullet \frac{S}{\sqrt{n}}$$

Where:

$\overline{X}$ is sample mean

$t_{\alpha/2,n-1}$ is at 95% confidence interval

μ is population mean

S is standard deviation of sample data

n is number of sample

Chapter 4

STATISTICAL ANALYSIS AND RESULTS

4.1 Distribution of Results

Total of 232 questionnaires were distributed in all. Out of 232, 101 responses were collected. But 9 responses were incomplete and discarded. Hence total of 92 valid responses are considered for further analysis with distribution as under:-

a. Distribution by hand ----------16
   Distribution by internet/online----------24
b. Visits on site----------33
c. Visits to offices----------19

This number yields a response ratio of 40.5%. Although the author was expecting lesser ratio but this response ratio was basically achieved due to the personnel visits of the author to the sites and offices and having personnel meeting with the respondents. This eased the way to the better explanation of the questions and more realistic picture can be drawn. The major reasons for the non-responsive behaviors are the length of the questionnaire, poor understanding of the terms used by the respondents, and the lower interest/hectic routine of the respondents.

4.2 Presentation of Results

The results are presented below:-

4.2.1 Respondents' Attributes

To determine the respondent's attributes, 6 questions are drafted in the questionnaire. These questions are:

a. Name
b. Organization in which employed
c. Position
d. Profession
e. Professional education level
f. Experience

4.2.1.1 Profession

By profession, summary of the responses are as shown in the Table 4.1:

Table 4.1: Summary - Profession

S/No	Profession	Responses	% Responses
1	Client	28	30.43
2	Contractor	38	41.30
3	Consultant	16	17.39
4	Academia/research	3	3.26
5	Others	4	4.34
6	Architect	3	3.26

By profession, 28 out of 92 that correspond to 30.43%, respondents are Clients. 38 respondents (41.30%) are contractors. 16 respondents (17.39%) are consultants. 3 of the respondents (3.26%) are from the academia as Professors/lecturers. 3 architects (3.26%) responded to the questionnaire whereas 4 respondents (4.34%) are from industries which are not included in the given profession.

4.2.1.2 Education

The questionnaires are distributed among the construction industry personnel that are only civil engineers/architects. Summary of responses in this category are given in Table 4.2:

Table 4.2: Summary - Education

S/No	Education	Responses	% Responses
1	Bachelor Degree	46	50
2	Degree Master	40	43.47826
3	Degree Doctorate	2	2.173913

Table 4.2: Summary - Education - Continued

S/No	Education	Responses	% Responses
4	Others	4	4.347826

46 out of 92 respondents corresponding to 50% have Bachelor's Degree in civil/architecting. 40 respondents (43.47%) have Master degree in civil engineering. 2 respondents (2.17%) have done the Doctorate whereas 4 respondents (4.34%) are not from the given category, out to which 3 have below bachelor's level education.

4.2.1.3 Position

The summary of the position of different respondents are given in Table 4.3:

Table 4.3: Summary - Position of the Respondent

S/No	Position	Responses	% Responses
1	Project Manager	26	28.2608696
2	Directors/Dy Directors/Managing Directors/assistant Director etc	21	22.826087
3	Project Engineers	13	14.1304348
4	Site Managers	6	6.52173913
5	Contract Administrator	5	5.43478261
6	Professors/Lecturers	4	4.34782609
7	Designer	7	7.60869565
8	Others	10	10.8695652

26 of the respondents are project managers corresponding 28.26% whereas 21(22.82%) are at the different directors levels. 13(14.14%) project engineers, 6 (6.52%) site managers, 5(5.43%) contract administrators, 4(4.37%) professors/lecturers, 7(7.6%) designers and 10(10.86%) others respondents responded on the questionnaire.

4.2.1.4 Experience

Data of the respondents are as shown below in Table 4.4:-

Table 4.4: Summary - Experience of the Respondent

S/No	Experience	Responses	% Responses
1	0-5 yrs	12	13.0434783
2	5-10 yrs	10	10.8695652
3	10-15 yrs	28	30.4347826
4	15-20 yrs	15	16.3043478
5	>20 yrs	27	29.3478261

12 respondents have experience between 0-5 years which corresponds to 13.04%. 10 respondents having experience of 5-10 years responded to the questionnaire with corresponding percentage of 10.86. The bulk of respondents have experience between 10-15 years and >20 years i-e 28 and 27 respectively. The percentage for the 10-15 years bracket is 30.43% whereas for >20 years bracket, it is 29.34%. 15 respondents have experience in range of 15-20 years with corresponding 16.30%.

4.2.2 Organizational Attributes

To determine the organizational attributes, 5 questions are drafted in the questionnaire. The aims of these questions are to find;

a. Time of operation since the organization is operational
b. Average number of employees employed.
c. Average capacity of organization in terms of cost to undertake a project

d. Major clients

e. Geographical operational locations

4.2.2.1 Operational time since its foundation

The summary statistics for operational time since the foundation of the organization shown in Table 4.5:-

Table 4.5: Summary - Operational Time

S/No	Time	Responses	% Responses
1	N/A	18	19.5652174
2	0-5 yrs	8	8.69565217
3	5-10 yrs	9	9.7826087
4	10-15 yrs	13	14.1304348
5	15-20 yrs	5	5.43478261
6	>20 yrs	39	42.3913043

8 respondents with 8.69% claim that their organization operational time since its creation is between 0-5 years. 9 (9.78%) respondents respond with the time between 5-10 years. 13 respondents (14.13%) say that their organization's operational time since its foundation ranges between 10-15 years. For the operational time between 15-20 years, 5 respondents(5.43%) responded whereas 39(42.39%) respondents have their organization operational time since its foundation greater than 20 years. There are 18(19.56%) respondents who are not sure or considers operational time since organization's foundation as not applicable to them.

4.2.2.2 Employees

The summary of average number of employees employed by the organizations is given below in Table 4.6:

Table 4.6: Summary - Average number of Employees

S/No	Numbers	Responses	% Responses
1	10-100	16	17.3913043
2	100-500	27	29.3478261
3	500-1500	20	21.7391304
4	>1500	25	27.173913
5	N/A	4	4.34782609

At an average 16 organizations employ 10-100 numbers of employees corresponding to 17.39%. 27 organizations have employed 100-500 numbers of employees which corresponds to 9.34%. There are 20 respondents (21.73%) who employ number of employees in the range of 500-1500. 25 respondents say that there organization employ greater then 1500 employees corresponding to 27.17%. 4 respondents (4.34%) are of the opinion that this question attribute is not applicable to them.

4.2.2.3 Project cost usually undertaken

The summary of cost ranges of usually undertaken projects by the organizations is given below in Table 4.7:-

Table 4.7: Summary - Projects Cost Usually Undertaken

S/No	Cost(M)	Responses	% Responses
1	0-100	18	19.5652174
2	100-200	8	8.69565217
3	200-300	13	14.1304348
4	300-400	7	7.60869565

Table 4.7: Summary - Projects Cost Usually Undertaken- Continued

S/No	Cost(M)	Responses	% Responses
5	400-500	5	5.43478261
6	>500	36	39.1304348
7	N/A	5	5.43478261

At an average 18 organizations usually undertake project in the cost range of 10-100M corresponding to 19.56%. 8 organizations undertake project in the cost range of 100-200M which corresponds to 8.69%. There are 13 respondents (14.13%) who undertake project in the cost range of 200-300M. 7 respondents say that there organizations carry out project in the cost range of 300-400M corresponding to 7.6%. 5 respondents (5.43%) are of the opinion that their organizations undertake projects in the cost range of 400-500M. 36 respondents (39.13%) say that their organizations usually undertake the project having cost greater than 500M. However 5 respondents (5.43%) are of the opinion that the question is not applicable to them.

4.2.2.4 Major Clients

The summary of major clients as indicated by the respondents is given below in Table 4.8

Table 4.8: Summary - Major Clients

S/No	Clients	Responses	% Responses
1	Public	25	27.173913
2	Both Public and Private	52	56.5217391
3	Private	6	6.52173913
4	N/A	9	9.7826087

At an average 25 organizations usually undertake project in the public sector only i-e Government projects corresponding to 27.17%. 52 organizations undertake project in both public and private sectors which corresponds to 56.52%. There are 6 respondents (6.52%) who undertake project in private sector only. However 9 respondents (9.78%) are of the opinion that the question is not applicable to them.

4.2.2.5 Geographical employment of the Organization

The summary of major clients as indicated by the respondents is given below in Table 4.9:

Table 4.9: Summary - Geographical Employments

S/No	Employment Geographical location	Responses	% Responses
1	All in the Country	62	67.3913043
2	Spread in the country and Abroad	25	27.173913
3	All abroad	3	3.26086957
4	N/A	2	2.17391304

At an average 62 respondents work in organizations which undertake projects only in Pakistan that correspond to 67.39%. 25 organizations undertake project in the Pakistan as well as abroad which correspond to 27.17%. There are 3 respondents (6.52%) who undertake projects in abroad only. However 2 respondents (9.78%) are of the opinion that the question is not applicable to them.

4.3 Reliability of the Sample

4.3.1 Cronbach's Coefficient Alpha Method

Cronbach's Coefficient Alpha method is the most common measure of internal consistency (reliability). It is most commonly used to check the reliability of scale when questions are asked on likert scale. If Cronbach's Coefficient Alpha value is higher than 0.7, this means that the data is acceptable for analysis (Li, 2007). The reliability test was performed on 84 answers specifically designed for measuring the lean conformance and its importance level. For the collected data, its value is calculated as 0.887 using SPSS, as given in Table 4.10. Its higher value indicates that the data is consistent and reliable for further analysis.

Table 4.10: Reliability Statistics

<table>
<tr><td colspan="4">Case Processing Summary</td><td rowspan="2">Cronbach's Alpha</td><td rowspan="2">0.887</td></tr>
<tr><td colspan="2"></td><td>N</td><td>%</td></tr>
<tr><td rowspan="3">Cases</td><td>Valid</td><td>92</td><td>100.0</td><td rowspan="3">Number of Items</td><td rowspan="3">84</td></tr>
<tr><td>Excluded[a]</td><td>0</td><td>.0</td></tr>
<tr><td>Total</td><td>92</td><td>100.0</td></tr>
<tr><td colspan="4">a. Listwise deletion based on all variables in the procedure.</td></tr>
</table>

4.3.2 Split-Half Method

It also checks the reliability of data while splitting it in two equal parts of 42 items each. For 1st part Cronbach’s Alpha value is 0.835 and for the 2nd part its value is 0.826. Higher value of Split-Half coefficient alpha (closer to 1) indicates that the data is quite reliable for further analysis.

Table 4.11: Reliability Statistics - Split Half Method

Cronbach's Alpha	Part 1	Value	**0.835**
		No of Items	42[a]
	Part 2	Value	**0.826**
		No of Items	42[b]
	Total No of Items		84
a. First 42 questions b. Last 42 questions			

4.4 Lean Conformance Answers

For measuring the lean conformance, total of 42 questions are made by duly incorporating the advice of experts in the industry. The total numbers of responses are 92. Thus total numbers of answers are 92x42 =3864. The frequencies of answers are as tabulated below in Table 4.12:-

Table 4.12: Summary - Frequencies of Answers

S/No	Answer Type	Frequency	Percentage Frequency
1	Never	172	4.45
2	Seldom	742	19.20
3	Sometimes	1464	37.88
4	Often	1062	27.48
5	Almost Always	366	9.47
6	N/A	54	1.39
7	Left Blank	4	0.10

As described earlier, the answer NEVER means that the respondents never performed the lean practices whereas the answer ALMOST ALWAYS means that the respondents always

perform and follow lean practices. As per the survey 172 respondents (4.45%) choose the answer NEVER. 742 Respondents choose the answer SELDOM which corresponds to 19.20%. 1462 respondents say that they SOMETIMES perform the lean practices corresponding to 37.88%. 1062 answer are OFTEN corresponding to 27.48%. 366 respondents (9.47%) have answered ALMOST ALWAYS. 54 respondents (1.39%) say that the question do not pertain to their respective organization or unsure of the question and marked N/A. However 4 respondents (0.10%) left the questions unanswered and BLANK. Summary of the result as tabulated in Table 4.12 is shown in Figure 4.1 below:

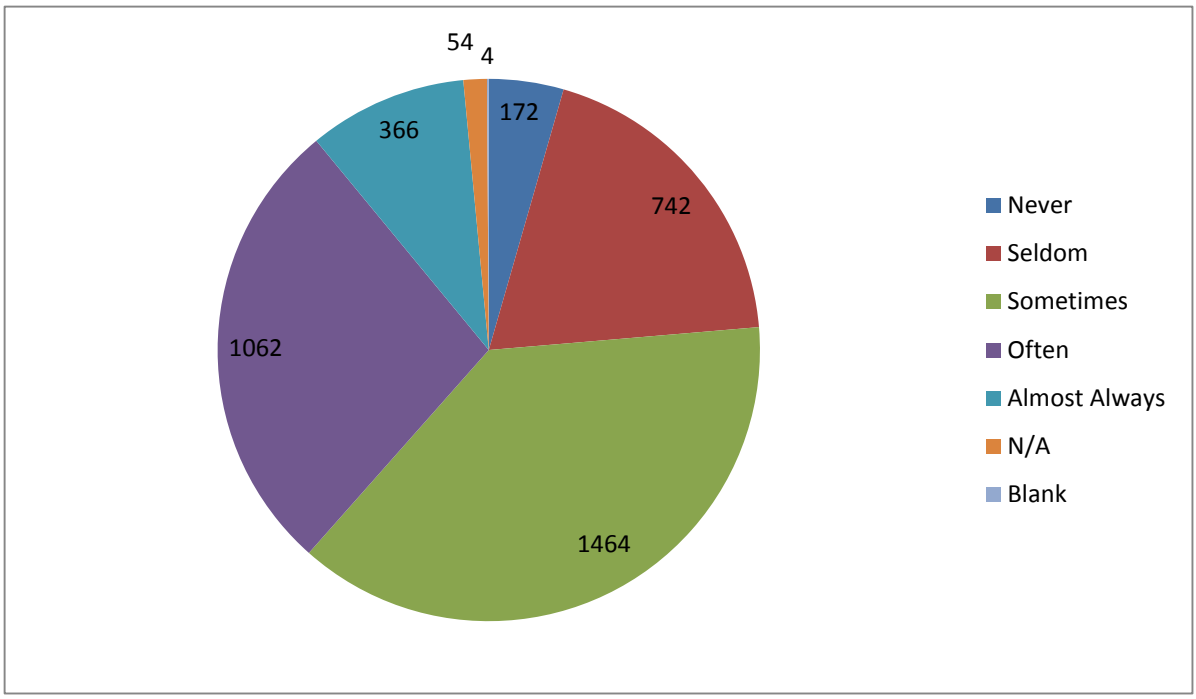

Figure 4.1: Answer's Frequency

4.4.1 Lean Conformance Answer's Quantitative conversion

To perform the quantitative analysis on the survey data, numerical values are given to the answers. These numerical values are as follows:-

Never	0
Seldom	1
Sometimes	2
Often	3

Almost Always	4
Blank	0

Answers of NEVER are given 0 score because the respondents have not utilized lean skill/practices ever and hence yields no contribution in the lean conformance of the organization. Answers SELDOM are given score 1 because of very little contribution towards lean conformance as the respondents have very rarely or almost negligibly used the lean skills mentioned. The answers SOMETIMES are given score of 2 because of the fact that respondents have practiced the respective lean skill/sub principle almost half times of their construction industry experience. The answer OFTEN is given the score 3 because the respondents have frequently used the lean sub principle. The highest score i-e 4 is given to the answer ALMOST ALWAYS which means that respondents regularly use the respective lean sub principle while undertaking any project. BLANK cells are given score 0 assuming that the respondents have left it blank because they don't follow or understand the respective lean sub principle. If the respondents don't understand the lean sub principle they can never implement it also.

4.4.2 Frequency of Scores for each Question

The description of questions formulated for finding the percent fulfillment of each sub principle is given in Appendix II. However frequency of scores is shown below in Table 4.13 respectively:

Table 4.13: Overall Summary of Frequencies - Lean Conformance Answers

Question Type	Answer Frequency					
	0	1	2	3	4	N/A
Culture/People						
People Involvement 1	2	4	30	42	14	0
People Involvement 2	1	4	23	36	28	0
People Involvement 3	1	9	28	38	16	0
Organizational Commitment 1	5	16	34	31	6	0
Organizational Commitment 2	9	30	38	13	2	0
Training	5	32	37	14	4	0
Total	23	95	190	174	70	0
% Total	4.16	17.21	34.420	31.52	12.681	0
Continuous Improvement/Build-in-Quality						
Metrics-1	2	25	40	24	1	0
Metrics-2	2	15	46	25	4	0
Response to Defects 1	3	20	38	27	3	1
Response to Defects 2	2	12	40	34	3	1
Response to Defects 3	3	32	35	20	1	1
Error Proofing 1	1	13	40	32	6	0
Error Proofing 2	1	19	43	22	7	0
Organizational Learning 1	3	12	25	36	16	0
Organizational Learning 2	2	19	38	26	7	0
Organizational Learning 3	1	8	21	32	30	0
Total	20	175	366	278	78	3
% Total	2.17	19.02	39.782	30.21	8.4782	0.326
Customer Focus						
Flexible Resources-1	3	15	36	34	4	0
Flexible Resources-2	1	10	44	30	7	0
Flexible Resources-3	0	7	21	25	39	0
Optimize Value-1	2	12	56	17	4	1
Optimize Value-2	0	21	47	18	5	1
Total	6	65	204	124	59	2
% Total	1.30	14.13	44.34	26.95	12.82	0.43
Eliminate Waste						
Supply Chain Management-1	2	18	34	27	7	4
Supply Chain Management-2	0	5	26	37	20	4
Supply Chain Management-3	2	5	16	33	33	3
Supply Chain Management-4	1	12	34	29	11	5
Optimize Production System-1	0	8	41	27	10	6
Optimize Production System-2	15	34	31	8	1	3
Optimize Production System-3	5	19	33	25	6	4
Optimize Production System-4	6	14	38	23	8	3
Reduce Process Cycle Time-1	1	11	23	37	15	5
Reduce Process Cycle Time-2	0	11	32	39	10	0
Reduce Process Cycle Time-3	19	45	16	9	3	0

Table 4.13: Overall Summary of Frequencies - Lean Conformance Answers - Continued

Question Type	Answer Frequency					
Reduce Process Cycle Time-4	1	39	36	12	2	2
Optimize Work Content 1	3	20	47	18	3	1
Optimize Work Content 2	1	14	46	24	3	4
Total	56	255	453	348	132	44
% Total	4.34	19.79	35.170	27.01	10.248	3.416
Standardization						
Visual Management-1	17	38	24	12	1	0
Visual Management-2	18	35	36	3	0	0
Visual Management-3	27	36	21	7	1	0
Workplace Organization 1	3	9	36	33	8	3
Workplace Organization 2	2	9	44	31	6	0
Defined Work Processes 1	1	11	48	26	4	2
Defined Work Processes 2	3	14	42	26	7	0
Total	71	152	251	138	27	5
% Total	11.0	23.60	38.975	21.42	4.1925	0.776
Grand Total	176	742	1464	1062	366	54
% Grand Total	4.55	19.20	37.888	27.48	9.4720	1.397

4.4.3 Analysis of Results – Lean Conformance

In this section the gathered data about lean construction conformance will be analyzed and various statistical tests will be performed to get descriptive statistics and further conclusions about the population will be made.

4.4.3.1 Lean Conformance - Overall

Measuring lean construction performances in the Pakistan construction is important as it gives the idea about where we are and what all we have to do to get us align with the standard practices of lean construction and get us tuned for the modern construction methodologies effectively being employed in the developed countries. After assigning the numeric values to the answers, the lean construction conformance is measured in percentages. There are 5 answers for each question with multiple choice scores of 0,1,2,3,4 and N/A. and total questions are 42. The N/A answers are given the score of 0 believing the fact that either the respondent is not aware of the lean statement/sub principle or he has no idea about the practice in his organization. In both the cases, the lean practice against those questions having answer N/A is not being followed in the organization. The N/A choice will also provide the cushion against unreasonable/ unrealistic answers. The lean conformance calculation in percentage was performed by this formula:

$$\text{Lean Conformance (\%)} = \frac{\text{Sum of all the actual answers x 100}}{\text{Sum of highest answer scores}} \qquad \text{F-1}$$

The lean conformance percentages for all the respondents were calculated. For each of the sub principle, individual lean practices were also calculated. These analyzes were performed using Microsoft Excel, PH, SPSS 20 and sigmaXL. The summary descriptive statistics for the sample lean conformance values (%) can be seen in Table 4.14. The graphical representation is also shown in Figure 4.2 to 4.4:

Table 4.14: Descriptive Statistics- Lean Conformance

Mean	**Median**	**Mode**	**Standard Deviation**	**Kurtosis**	**Skewness**	**Range**	**Min**	**Max**	**Count**
53.99	53.86	50.59	8.84	2.72	-0.027	59.52	27.97	87.5	92

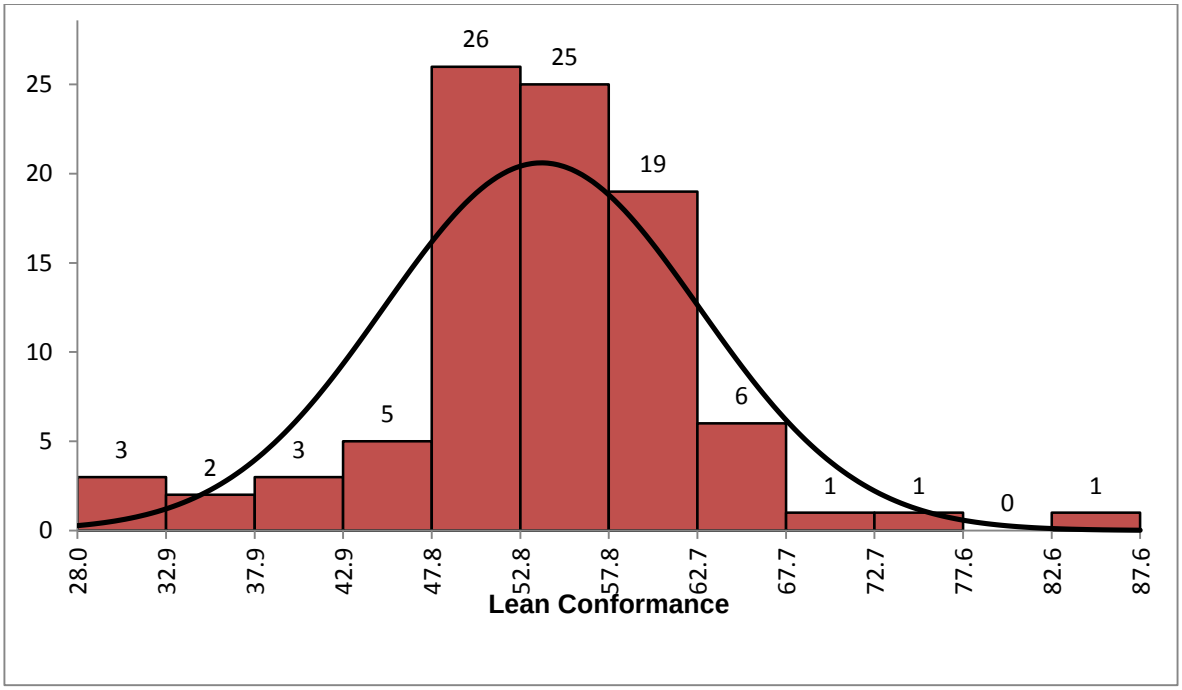

Figure 4.2: Histogram- Lean Conformance

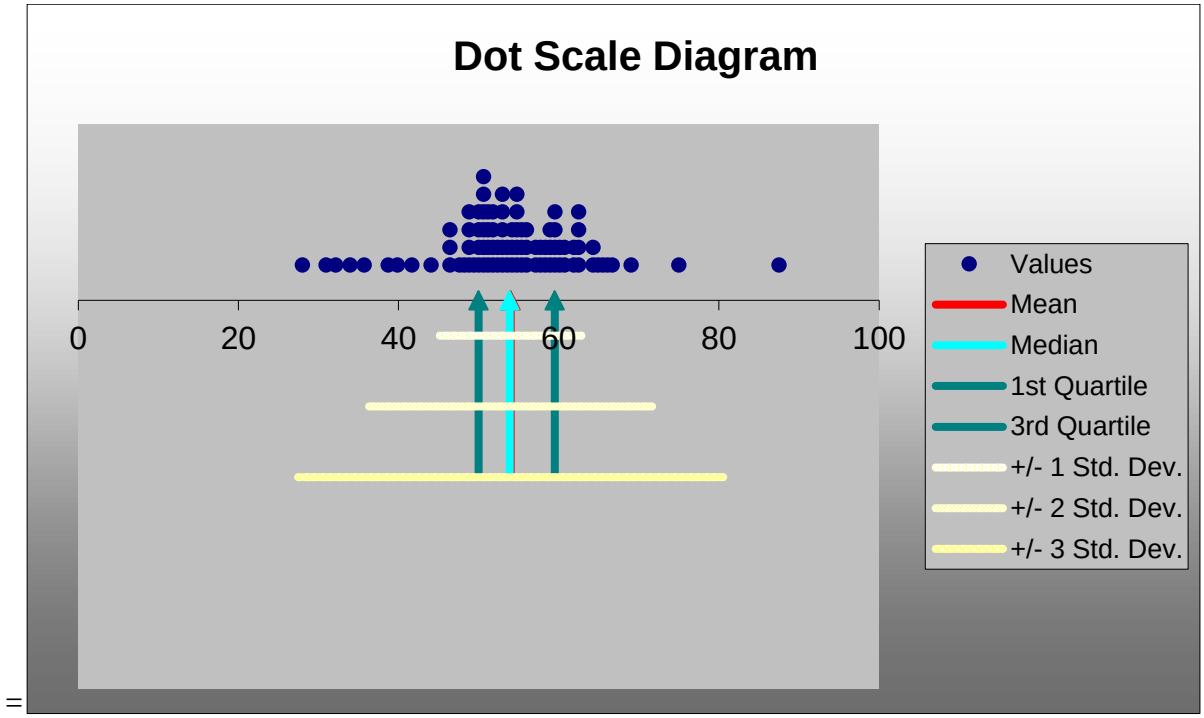

Figure 4.3: Dot Scale - Lean Conformance

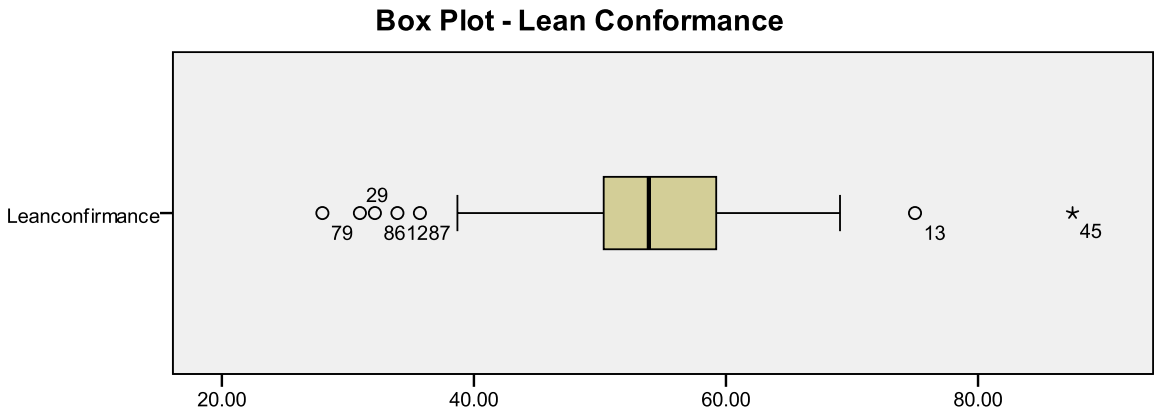

Figure 4.4: Box Plot 1- Lean Conformance

(Outliers are shown in circles and cross)

The value of skewness is quite reasonable as far as normality is concerned. However box plot output as calculated by spss software shows the presence of 6 minor and 1 extreme value/outlier in the data.

Normality test was performed using Anderson-Darling (A-D) test according to which if A-D p-value is greater then 0.05 at confidence interval of 95 percent (alpha -0.05) then the data is normal. To calculate the AD- p value, SigmaXL in Microsoft excel is used and output is shown below:-

Anderson-Darling Normality Test:

A-Squared = 1.551; p-value = 0.0005

Since A-D p-value is smaller then alpha value (0.05) hence the data set is not normal at 95% confidence interval. The same is confirmed by using Shapiro-Wilk test of normality by using SPSS software as under:-

Table 4.15: Tests of Normality(SPSS)-Lean Conformance

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Lean conformance	.127	92	.001	.943	92	.001

a. Lilliefors Significance Correction

The p-value is still less than the alpha value-0.05.

Hence it is concluded that at 95 percent confident interval we reject the null hypothesis and our data of lean conformance is not normal.

In order to make the set data normal, certain steps can be performed. The complete data set can either be transformed or outliers can be removed. In first step, the complete data was again observed critically specially for the outliers. The aim of this observation was to see whether any process errors or data entry errors have caused these outliers. After carefully observing the outliers, it was revealed that four out of 7 outliers were the responses from the engineers (Pakistani) who are working in the abroad with foreign firms/universities. 2 are professors in foreign universities and 2 are working in the foreign firms. Hence their responses will not be significant in analyzing the lean conformance with respect to Pakistani Industry. Complete data was checked again to see any further foreign response. 2 more responses from foreign countries were received out of which 1 engineer is employed in Pakistani based firm which is working in that country as well and other one has recently employed in that foreign based firm. Hence both these responses were not deleted and kept in the data. 1 response though from Pakistani consultant firm working in Pakistan but the experience level of the respondent was very less. He just joined the firm after the Bachelor's degree. Hence it would be more appropriate to delete them. 5 responses basically outliers, because of no contribution in the analysis for the Pakistan construction industry were deleted. Remaining 2 outliers cannot be deleted because of neither process nor entry errors. The results are as tabulated in Table 4.16:-

Table 4.16: Test for Normality after critical review

Delete ser number in Box plot	Original values	Sig P value after deleting
13,29,45,79 (only foreign based)	33.93,30.95,87.5,27.98	0.0386
13,29,45,79,86 (all 5 responses)	33.93,30.95,87.5,27.98,32.142	0.124

Certain descriptive like histogram and box plot are given below after deletion of the outliers as shown in Figure 4.5 and 4.6:-

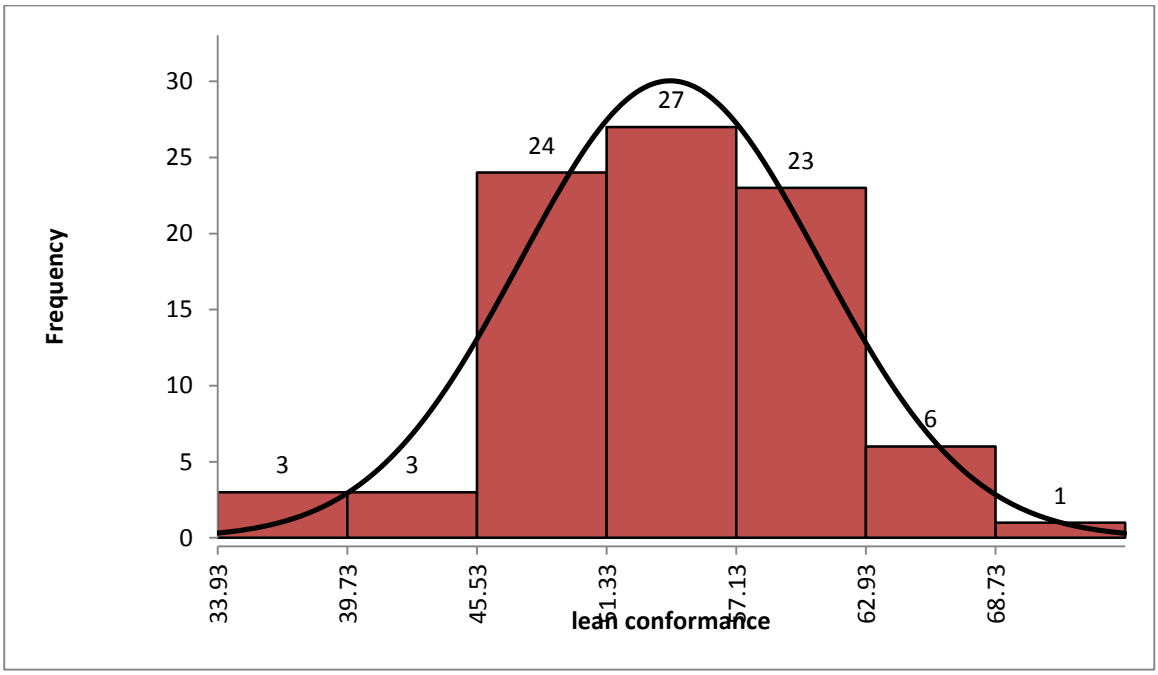

Figure 4.5: Histogam- Lean Conformance after review

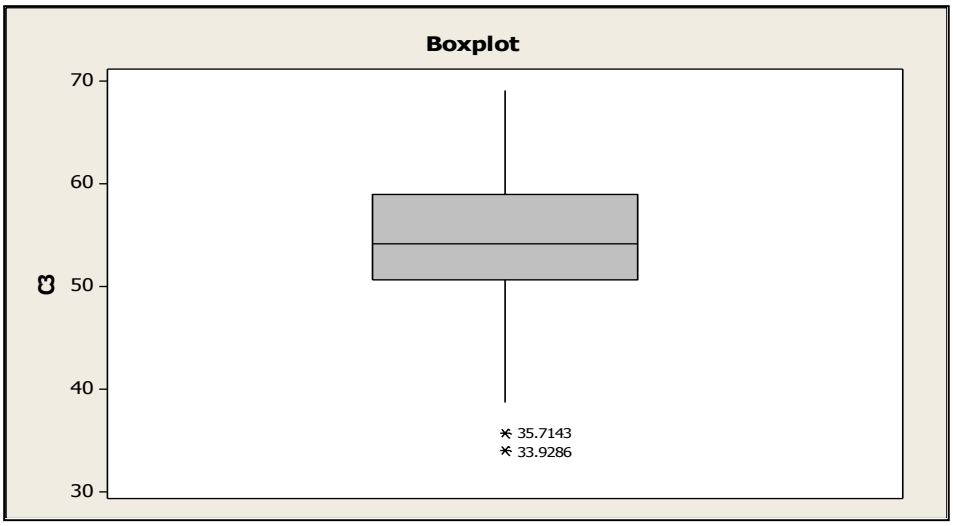

Figure 4.6: Box Plot - Lean Conformance

Descriptive statistics after the deletion of the outliers is as shown in Table 4.17

Table 4.17: Descriptive Statistics- Lean Conformance after Deletion of Outliers

Mean	Median	Mode	Standard Deviation	Kurtosis	Skewness	Range	Minimum	Maximum	Count	Sample variance
54.18	54.16	50.59	6.70	0.73	-0.41	35.11	33.92	69.04	87	44.92

By now sample mean ($\overline{X}$), sample standard deviation(s) and variance (s^2) are known and also we know that our data set is normalized. With the help of simple t statistics, the confidence interval for the population mean (μ) can be defined with the help of following formula:

$$\overline{X} - t_{\alpha/2,n-1} \bullet \frac{S}{\sqrt{n}} \leq \mu \leq \overline{X} + t_{\alpha/2,n-1} \bullet \frac{S}{\sqrt{n}} \qquad \text{F-(2)}$$

The sample size is 87 (n) and the level of confidence was selected as 95% (α/2 = 0.025). The $\overline{X}$ and S values were taken from the data set modified after necessary adjustment. Since there is no ν = 86 (n-1) value corresponding to 97.5% in the t-test Table. A linear interpolation between ν = 80 (1.990) and ν = 90 (1.987) was performed. The values are

as: $\overline{X}$ = 54.18, S = 6.70, n-1 = 86, $t_{0.025,86}$ = 1.9882. Therefore, the population average (μ), with 95% confidence interval, can be determined by using formula F- (2) as:

52.744<=μ<=55.616

So it is inferred that population mean will be less or equal to 55.616% and greater or equal to 52.744% at a confidence interval of 95 percent.

4.4.3.2 Percent Fulfillment of Principles and Sub - Principles

The individual statistics of all the principles/Sub principles is necessary to evaluate the lean conformance. It will give a clear idea of how the Pakistan construction industry behaves in response to each individual principle. Percent fulfillment of each principle is calculated by using the following formula:

Percent Fulfillment= B x 100/A F-(3)

Where B= sum of individual scores of each sub principle answers in respective principle

A = Sum of maximum possible score of each sub principle answer in respective principle

Percent fulfillment of each principle is calculated for individual responses and the overall fulfillment is calculated by taking the average/mean of all the percent fulfillments of same principle in individual responses. Descriptive statistics for the percent fulfillment of each principle rankwise is given in Table 4.20:

There are 16 sub-principles which finally dissolve into 5 main principles as already explained in the section 3.1. The lean conformance percent fulfillment of each of these sub principles is calculated by taking the sum of individual scores for all the question's answers designed for that respective sub principle. The sum is divided by the sum of maximum possible scores for all the respective answers for the questions of respective sub principle. Finally multiply by 100 to get the percent. Formula is as shown below:-

Percent Fulfillment of sub principles = (the sum of individual scores for all the question's answers designed for that respective sub principle/ sum of maximum possible scores for all the respective answers for the questions of respective sub principle) x 100 F-(4)

The summary of the percent fulfillment of lean conformance sub principles rankwise are given below in Table 4.21

The overall summary for the percent fulfillment for individual questions is given below in Table 4.23. Percent fulfillment is calculated by adding all the individual response scores of respective questions and dividing them by the maximum possible score for that respective question i-e 4 x 87=348.

4.5 Analysis of Results - Importance Level of Lean construction

A part from measuring the lean conformance practices in the Pakistan construction industry, 42 questions were specifically drafted and included in the questionnaire to check the importance level of the lean conformance in the Pakistan in addition to the 42 lean conformance questions. At the end of each sub principle conformance questions, importance level of that particular sub principle was checked. The specimen of the questionnaire is already given in Appendix II.

For the analysis purposes the scores are given to each answer as follows:-

Hardly ever	0
Sometimes	1
Most of the times	2

To measure the importance level of the individual response, same formula F-1 is used as for measuring the lean conformance. The summary of descriptive statistics is shown below in Table 4.18:

Table 4.18: Descriptive Statistics- Importance Level

Mean	Median	Mode	Standard Deviation	Kurtosis	Skewness	Range	Minimum	Maximum	Count	A-D p value
81.91	82.14	82.14	12.75	0.414	-0.85	55.95	44.04	100	87	0.001

The value of the Anderson Darling p value is quite less than the 0.05 i-e at 95 percent confidence interval as already discussed in section 4.3.3.1. Hence the data is transformed by

using Box-Cox power transformation to make it good fit for normality. Box Cox uses the value of lambda which is a shape parameter and is derived by the software using the particular shape of the distribution. Using the sigmaXL, the lambda value of 3 was used to transform the data and transformed values are:

Z=x^3 where x is the original value and Z is the transformed value.

After the transformation the descriptive statistics is as under:-

Table 4.19: Descriptive Statistics- Importance Level after Transformation

Mean	Median	Mode	Standard Deviation	Kurtosis	Skewness	Range	Minimum	Maximum	Count	A-D P Value
587376.2	554254.7	554254.7	234703.6	-0.65423	-0.13074	914539.1	85460.87	1000000	87	0.3813

The histogram after and before transformation is as under:-

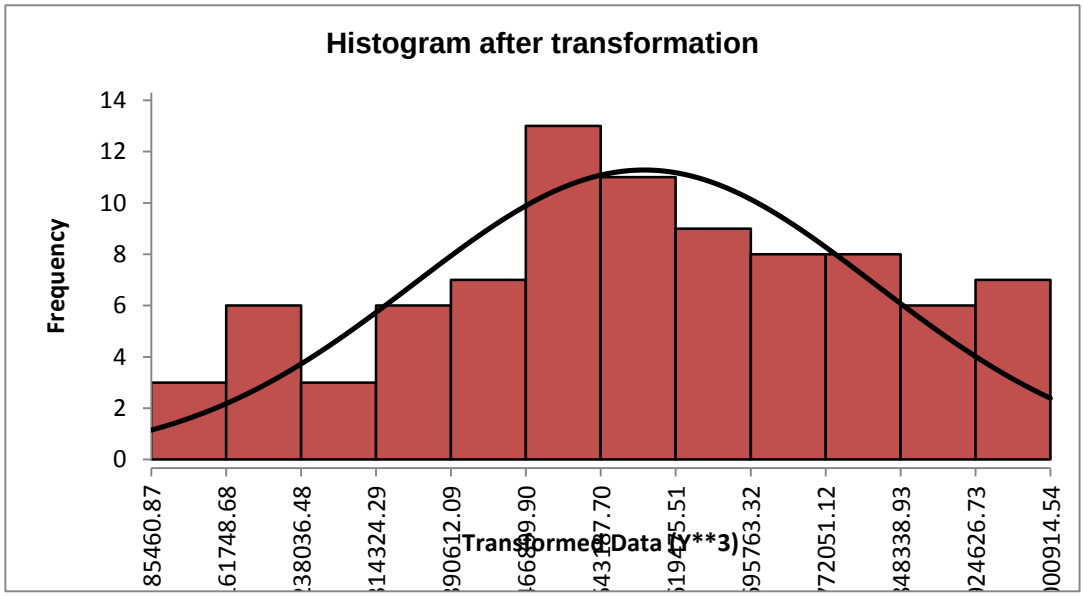

Figure 4.7: Histogram Importance Level- After Transformation

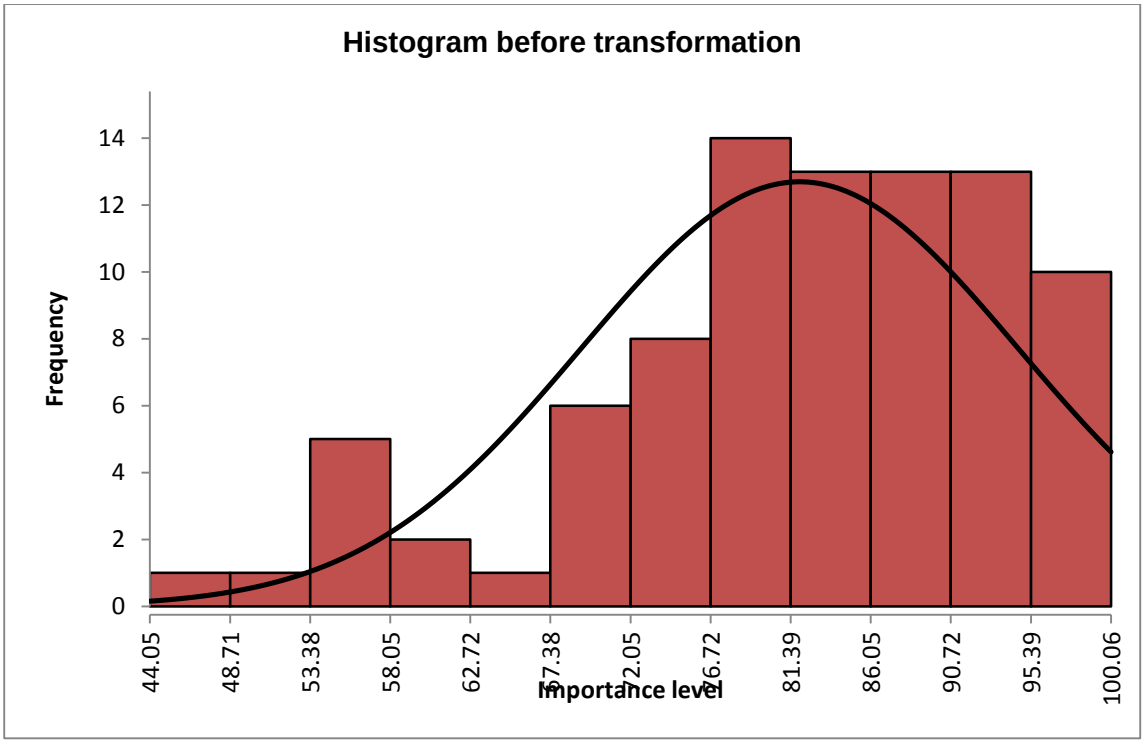

Figure 4.8: Histogram Importance Level- Original Value

The shape of the curve after transformation is convincingly normal and also the A-D p value is quite reasonable enough to reject the alternate hypothesis as given in section 4.3.3.1. And we can say that at 95 percent confidence interval, the data set after box cox transformation is normally distributed. The data given in Table 4.23 can be converted to original value by taking the power root as 1/3. To give the inference for the population mean, t statistics as explained above in section 4.3.3.1 is applied and using the formula F-(2), the mean value at 95 percent confidence interval is :

537062.43<=μ<=637689.9

Transforming back to the original value i-e to take power root as 1/3, the population mean for the importance of lean conformance principles in Pakistan at 95 percent confidence interval is:-

81.28<=μ<=86.07

4.5.1 Importance Level of principles, sub principles and individual questions

To determine the importance level of each principle and sub principle in percent, the same formula is used as given in formula F-(3) and F-(4) respectively. The results are shown in Table 4.23, 4.24 and 4.25 respectively.

4.6 Summary of the Analysis

So far two important inferences are made i-e the lean construction conformance in the Pakistan Construction industry at 95 percent confidence interval is between 52.744% and 55.616% and the importance of the lean construction among the construction stakeholders of Pakistan at 95 percent confidence interval is between 81.28% and 86.07%. The rank wise percent fulfillment of the principles, sub principles and individual lean conformance questions are as shown below in following Tables:

Table 4.20: Rank wise Percent Fulfillment - Principles

Principles	Percent Fulfillment
Customer Focus	59.13
Cultural/People	57.8
Continuous improvement	56
Eliminate Waste	53.5
Standardization	45.23

Table 4.21: Rank wise Percent Fulfillment - Sub principles

Sub principles	Percent Fulfillment
People involvement	68.67
Flexible Resources	64.17
supply chain management	63.86
Organizational Learning	63.79
Work place Organization	57.9
Error Proofing	56.46
Defined Work Processes	55.17
Optimize Value	51.58
Metrics	51.14
Response to Defects	51.14
Optimize Work	50.57
Reduce process cycle	49.56
optimize production	48.56
Organizational commitment	48.27
Training	44.25
Visual Management	30.17

Table 4.22: Rank wise Percent Fulfillment – Individual Questions

Type of Question	Percent fulfillment
Flexible Resources-3	76.72414
Supply Chain Management-3	75
People Involvement 2	73.85057
Organizational Learning 3	73.27586
Supply Chain Management-2	68.3908
People Involvement 1	66.66667
People Involvement 3	65.51724
Organizational Learning 1	64.08046
Reduce Process Cycle Time-2	62.93103
Reduce Process Cycle Time-1	62.64368
Flexible Resources-2	58.90805
Error Proofing 1	58.62069
Supply Chain Management-4	58.33333
Workplace Organization 1	58.33333
Optimize Production System-1	58.04598
Workplace Organization 2	57.47126
Response to Defects 2	56.89655
Flexible Resources-1	56.89655
Defined Work Processes 1	55.45977
Organizational Commitment 1	55.17241
Defined Work Processes 2	54.88506
Error Proofing 2	54.31034
Organizational Learning 2	54.02299
Supply Chain Management-1	53.73563
Metrics-2	52.87356
Optimize Value-1	52.29885
Optimize Work Content 2	52.29885
Optimize Production System-4	52.01149
Response to Defects 1	51.72414
Optimize Value-2	50.86207
Optimize Production System-3	50.57471
Metrics-1	49.42529
Optimize Work Content 1	48.85057
Response to Defects 3	44.82759
Training	44.25287
Reduce Process Cycle Time-4	41.95402
Organizational Commitment 2	41.37931
Optimize Production System-2	33.62069
Visual Management-1	33.33333
Reduce Process Cycle Time-3	30.74713
Visual Management-2	30.74713
Visual Management-3	26.43678

Similarly rank wise importance level of the principles, sub principles and individual questions in percentage realized by the stakeholders of Pakistan construction industry are given in following Tables:

Table 4.23: Rank wise Importance Level of Principles in Percentage

Continuous improvement	85.8
Cultural/People	83.04
Customer Focus	82.52
Eliminate Waste	81.36
Standardization	76.02

Table 4.24: Rank wise-Sub principle Importance Level in Percentages

Type of Question	**Importance Level (**%)
Metrics	87.06896552
Response to Defects	86.39846743
Organizational Learning	86.20689655
Defined Work Processes	85.91954023
People Involvement	84.29118774
Flexible Resources	84.29118774
Optimize Work Content 2	83.90804598
Supply Chain Management	83.33333333
Error Proofing	83.04597701
Reduce Process Cycle Time	82.04022989
Organizational Commitment	81.6091954
Training	81.25
Workplace Organization	81.03448276
Optimize Value	79.88505747
Optimize Production System	77.44252874
Visual Management	66.09195402

Table 4.25: Rank wise - Individual Questions Importance Level in Percentages

Type of Question	Importance Level (%)
Response to Defects 2	89.7727273
Organizational Learning 2	88.6363636
Metrics-2	88.0681818
Defined Work Processes 2	86.3636364
Flexible Resources-3	85.7954545
Supply Chain Management-3	85.7954545
Optimize Production System-4	85.7954545
Reduce Process Cycle Time-1	85.7954545
Organizational Learning 3	85.2272727
Supply Chain Management-2	85.2272727
People Involvement 3	84.0909091
Organizational Commitment 2	84.0909091
Metrics-1	84.0909091
Response to Defects 1	84.0909091
Flexible Resources-2	84.0909091
People Involvement 1	83.5227273
Optimize Production System-3	83.5227273
Reduce Process Cycle Time-2	83.5227273
Defined Work Processes 1	83.5227273
Optimize Value-2	82.9545455
Optimize Work Content 1	82.9545455
Optimize Work Content 2	82.9545455
People Involvement 2	82.3863636
Response to Defects 3	82.3863636
Error Proofing 2	82.3863636
Supply Chain Management-1	82.3863636
Workplace Organization 1	82.3863636
Error Proofing 1	81.8181818
Organizational Learning 1	81.8181818
Training	81.25
Flexible Resources-1	80.1136364
Reduce Process Cycle Time-4	77.8409091
Workplace Organization 2	77.8409091
Organizational Commitment 1	77.2727273
Reduce Process Cycle Time-3	77.2727273
Supply Chain Management-4	76.1363636
Optimize Value-1	75
Optimize Production System-1	75
Visual Management-1	68.1818182
Visual Management-2	64.2045455
Visual Management-3	63.6363636
Optimize Production System-2	61.9318182

4.7 Important Comparisons between different attributes

The data set was gathered from different attributes of the construction industry as already explained in the section 4.2.1 and 4.2.2. Now the comparisons between different vital categories within the attributes are important to draw major conclusions from the data. Categories are selected based upon the number of response in these categories. The categories having more responses are compared and lesser responses are not compared unless these are important. The summaries of necessary comparison for both lean conformances as well as importance level are shown below in Table 4.26 and Table 4.27 respectively:

Table 4.26: Rank Wise Comparisons of Attributes/Groups- Lean Conformance - Principles

Categories	Count	Cultural/People	Continuous Improvement/ Build-in-Quality	Customer Focus	Eliminate Waste	Standardization	Overall lean conformance
Projects cost (M)							
400-500	5	65.83	59.00	61.00	60.36	48.57	58.93
>500	35	59.64	55.93	59.57	58.11	48.78	56.43
300-400	6	54.17	65.00	65.83	48.81	40.48	54.07
200-300	13	54.81	57.12	59.23	49.04	39.56	51.42
0-100	18	55.79	54.58	59.72	49.80	40.28	51.39
100-200	7	56.55	50.00	48.57	48.21	51.53	50.43
Major Clients							
Private	5	60.83	56.00	54.00	55.36	45.00	54.40
Both Private and Public	50	58.42	55.30	59.80	54.82	43.93	54.23
Public	25	58.00	56.90	58.20	50.36	47.29	53.43

Table 4.26: Rank Wise Comparisons - Lean Conformance – Principles (Continued)

Categories	Count	Cultural/People	Continuous Improvement/ Build-in-Quality	Customer Focus	Eliminate Waste	Standardization	Overall lean conformance
Experience level (years)							
5-10	10	49.54	58.89	60.00	59.52	45.63	55.69
>20	26	60.10	57.60	61.92	52.27	44.37	54.49
0-5	12	63.19	56.25	57.08	51.19	49.11	54.46
10-15	24	55.21	54.48	57.50	53.87	43.30	52.88
15-20	15	57.78	53.17	56.67	52.38	46.43	52.86
Profession							
Contractors	38	57.66	54.53	61.35	56.61	44.79	54.86
Clients	27	55.86	55.56	57.78	52.78	47.75	53.64
Consultant	15	60.83	62.17	58.00	47.62	43.33	53.49
Position							
Director title	21	61.31	58.45	62.38	53.15	46.94	55.64
project engineer	13	55.45	59.62	57.69	55.36	45.60	55.04
Site managers	6	63.89	55.83	61.67	50.00	47.62	54.37
project manager	26	54.81	53.17	58.85	56.18	46.02	53.89
Education							
Masters	39	59.29	58.27	58.33	53.21	47.89	55.01
Batchelors	44	56.63	54.26	59.66	53.90	43.43	53.31
Operational time (Years)							
0-5	6	64.06	58.44	54.38	50.67	54.02	55.43
5-10	9	57.41	52.22	53.89	62.30	45.63	55.42
>20	36	57.52	58.13	61.53	53.57	44.44	54.65

Table 4.26: Rank Wise Comparisons - Lean Conformance – Principles (Continued)

Categories	Count	Cultural/People	Continuous Improvement/ Build-in-Quality	Customer Focus	Eliminate Waste	Standardization	Overall lean conformance
10-15	12	62.15	56.04	59.17	47.62	45.54	52.73
15-20	4	53.13	53.75	62.50	53.57	41.07	52.53
Employees (Numbers)							
>1500	24	59.90	56.88	62.50	57.07	46.73	56.35
100-500	26	57.21	56.44	58.08	53.37	46.98	54.14
500-1500	19	56.58	54.61	56.84	55.55	46.05	54.04
10-100	14	57.14	55.89	59.29	46.05	41.33	50.77
Geographical location							
Spread in the country and abroad	23	60.51	58.48	60.00	52.41	47.52	55.10
All in the country	60	56.32	55.42	58.25	53.24	43.75	53.21
Projects cost (M)							
0-100	18	86.57	88.06	89.44	87.10	84.13	87.04
>500	35	85.95	89.00	85.14	81.53	76.33	83.50
400-500	5	78.33	82.00	84.00	79.29	71.43	79.05
200-300	13	76.92	82.31	78.46	80.49	69.78	78.39
300-400	6	80.56	80.83	71.67	79.17	73.81	77.98
100-200	7	77.38	75.71	70.00	75.51	73.47	74.83
Major Clients							
Both Private and Public	50	83.33	87.20	84.20	83.50	78.14	83.55
Public	25	85.00	84.40	80.80	79.71	75.14	80.95

Table 4.27: Rank Wise Comparisons of Attributes/Groups- Importance Level – Principles

Categories	Count	Cultural/People	Continuous Improvement/ Build-in-Quality	Customer Focus	Eliminate Waste	Standardization	Overall importance level
Private	5	86.67	85.00	76.00	79.29	64.29	78.81
Experience level (years)							
15-20	15	83.33	86.33	86.00	82.62	84.29	84.29
5-10	10	80.56	84.44	84.44	86.11	80.16	83.73
10-15	28	79.51	87.50	85.00	83.63	72.92	82.34
>20	26	86.86	86.35	78.46	81.18	74.45	81.78
0-5	12	82.64	81.67	81.67	72.32	72.62	77.18
Profession							
Contractors	38	85.14	87.03	84.05	83.40	75.10	83.20
Consultant	15	84.44	86.33	83.33	81.90	74.76	82.30
Clients	27	79.32	84.63	81.48	76.85	77.25	79.67
Position							
project manager	26	83.97	87.31	86.15	84.62	81.32	84.80
Site managers	6	90.28	90.00	78.33	83.33	73.81	83.73
Director title	21	87.30	83.57	82.38	80.10	74.15	81.24
project engineer	13	73.72	78.46	83.08	76.65	70.33	76.37
Education							
Batchelors	44	86.17	87.16	84.09	82.22	75.65	83.09
Masters	39	80.34	86.41	81.03	80.31	76.92	81.29
Operational time (Years)							
10-15	12	81.94	85.42	80.83	82.74	78.57	82.34

Table 4.27: Rank Wise Comparisons - Importance Level – Principles (Continued)

Categories	Count	Cultural/People	Continuous Improvement/Build-in-Quality	Customer Focus	Eliminate Waste	Standardization	Overall importance level
15-20	4	81.25	81.25	92.50	80.36	75.00	81.25
5-10	9	85.19	83.89	75.56	82.94	72.22	80.82
>20	36	83.80	86.25	82.22	79.56	71.23	80.69
0-5	8	72.92	77.50	81.25	77.23	74.11	76.64
Employees (Numbers)							
>1500	24	87.15	90.83	89.58	84.08	75.89	85.42
10-100	14	81.55	82.14	82.14	82.14	78.57	81.46
500-1500	19	83.33	86.32	77.89	80.08	76.69	81.20
100-500	26	79.81	83.27	80.00	78.57	72.53	79.03
Geographical location							
Spread in the country and abroad	23	84.78	88.70	82.17	81.37	77.33	83.02
All in the country	60	82.36	85.08	82.33	81.31	75.24	81.47

4.8 Tests for checking the differences between groups within attributes

Kruskill Wallis and one way ANOVA tests as described in section 3.5.2 were performed to determine whether all the groups with in the same attribute have similar perception about the lean conformance and the importance level. From the results it is revealed that all the groups with in all the attributes have same perception about lean conformance except in attribute of project cost usually undertaken and number of employees. To see which two groups with in these two attributes have difference in perception, Mann Whitney test for two independent variables was performed and revealed that the organizations/firm which undertake projects greater than 400 Million and employs more number of employees perform relatively better lean practices as compared to smaller organizations/firm. Whereas regarding importance

level all the groups with in respective attributes have similar perceptions The results for the two attributes of project cost usually undertaken and number of employees are shown below:

Table 4.28: Project Cost Usually undertaken

		N	Mean	Normality Sig Shapiro-Wilk	Equal Variance Sig	Kruskal-Wallis Test Sig	One Way Anova
Lean Conformance	>500	35	56.4286	.050	0.032	0.008	-
	0-100	18	51.3889	.566			
	100-200	7	50.4252	.559			
	200-300	13	51.4194	.967			
	300-400	6	54.0675	.005			
	400-500	5	58.9286	.335			
	Total	84	54.0533				
Cultural/People	>500	35	59.6429	.026	0.242	0.456	
	0-100	18	55.7870	.487			
	100-200	7	56.5476	.262			
	200-300	13	54.8077	.571			
	300-400	6	54.1667	.039			
	400-500	5	65.8333	.254			
	Total	84	57.7877				
Continuous Improvement /Inbuilt quality	>500	35	55.9286	.334	0.149	0.217	
	0-100	18	54.5833	.960			
	100-200	7	50.0000	.022			
	200-300	13	57.1154	.065			
	300-400	6	65.0000	.189			
	400-500	5	59.0000	.227			
	Total	84	56.1607				
Customer Focus	>500	35	59.5714	.112	0.238	0.124	
	0-100	18	59.7222	.180			
	100-200	7	48.5714	.099			
	200-300	13	59.2308	.004			
	300-400	6	65.8333	.566			
	400-500	5	61.0000	.329			
	Total	84	59.1667				
Eliminate Waste	>500	35	58.1122	.728	0.498	0.006	0.010
	0-100	18	49.8016	.006			
	100-200	7	48.2143	.370			
	200-300	13	49.0385	.579			

Table 4.28: Project Cost Usually Undertaken-Continued

		N	Mean	Normality Sig Shapiro-Wilk	Equal Variance Sig	Kruskal-Wallis Test Sig	One Way Anova
	300-400	6	48.8095	.013			
	400-500	5	60.3571	.875			
	Total	84	53.5714				
Standardization	>500	35	48.7755	.217	0.452	0.052	0.026
	0-100	18	40.2778	.239			
	100-200	7	51.5306	.665			
	200-300	13	39.5604	.832			
	300-400	6	40.4762	.066			
	400-500	5	48.5714	.421			
	Total	84	45.1531				

The p values for overall lean conformance and its principles Eliminate Waste and standardization are lower than 0.05 indicating that one or more group have dissimilar perceptions about the lean conformance. To check which two groups have dissimilar perception, Mann Whitney test was performed between every group and results are as under:

Table 4.29: Project Cost Usually Undertaken Vs Overall Lean Conformance

Compared by Group	Compared to Group	Sig
>500	0-100	.010
>500	100-200	.014
>500	200-300	.068
>500	300-400	.912
>500	400-500	.326
400-500	0-100	0.005
400-500	100-200	.007
400-500	200-300	.076
400-500	300-400	0.233
300-400	0-100	0.089
300-400	100-200	0.045

Table 4.29: Project Cost Usually Undertaken Vs Overall Lean Conformance -Continued

Compared by Group	Compared to Group	Sig
300-400	200-300	0.380
200-300	0-100	0.952
200-300	100-200	0.811
100-200	0-100	0.449

Table 4.30: Project Cost Usually Undertaken Vs Sub principle 4 Eliminate Waste

Compared by Group	Compared to Group	Sig
>500	0-100	.008
>500	100-200	.007
>500	200-300	0.007
>500	300-400	0.251
>500	400-500	0.525
400-500	0-100	0.040
400-500	100-200	0.051
400-500	200-300	0.068
400-500	300-400	0.199
300-400	0-100	0.546
300-400	100-200	0.350
300-400	200-300	0.428
200-300	0-100	0.409
200-300	100-200	0.873
100-200	0-100	0.445

Table 4.31: Project Cost Usually Undertaken Vs Sub principle 5 Standardization

Compared by Group	Compared to Group	Sig
>500	0-100	0.013
>500	100-200	0.644
>500	200-300	0.20
>500	300-400	0.227
>500	400-500	0.853
400-500	0-100	0.230
400-500	100-200	0.624
400-500	200-300	0.216
400-500	300-400	0.233
300-400	0-100	0.712
300-400	100-200	0.314
300-400	200-300	0.701
200-300	0-100	0.747
200-300	100-200	0.081
100-200	0-100	0.055

The results clearly indicated that the organizations undertaking projects of more financial value have different in perception as regard to organizations/firm undertaking relatively lesser financial value projects.

Table 4.32: Number of Employees-Difference in Perceptions

		N	Mean	Normality Sig Shapiro-Wilk	Equal Variance Sig	Kruskal-Wallis Test Sig	One Way Anova
Lean Conformance	>1500	24	56.3492	.762	0.157	0.034	-
	10-100	14	50.7653	.964			
	100-500	26	54.1438	.794			
	500-1500	19	54.0414	.003			
	Total	83	54.1882				
Cultural/People	>1500	24	59.8958	.057	0.082	0.714	-
	10-100	14	57.1429	.625			
	100-500	26	57.2115	.017			
	500-1500	19	56.5789	.964			
	Total	83	57.8313				
Continuous Improvement /Inbuilt quality	>1500	24	56.8750	.884	0.173	0.997	-
	10-100	14	55.8929	.220			
	100-500	26	56.4423	.690			
	500-1500	19	54.6053	.018			
	Total	83	56.0542				
Customer Focus	>1500	24	62.5000	.338	0.449	0.308	0.342
	10-100	14	59.2857	.178			
	100-500	26	58.0769	.332			
	500-1500	19	56.8421	.054			
	Total	83	59.2771				
Eliminate Waste	>1500	24	57.0685	.268	0.172	0.051	0.019
	10-100	14	46.0459	.039			
	100-500	26	53.3654	.841			
	500-1500	19	55.5451	.392			
	Total	83	53.7005				
Standardization	>1500	24	46.7262	.442	0.399	0.514	0.489
	10-100	14	41.3265	.999			
	100-500	26	46.9780	.729			
	500-1500	19	46.0526	.425			
	Total	83	45.7401				

Table 4.33: Number of Employees Vs Sub principle Eliminate Waste

Compared by Group	Compared to Group	Sig
>1500	10-100	0.028
	100-500	0.147
	500-1500	0.357
500-1500	10-100	0.086
	100-500	0.489
100-500	10-100	0.172

Table 4.34: Number of Employees Vs Overall Lean Conformance

Compared by Group	Compared to Group	Sig
>1500	10-100	0.031
	100-500	0.139
	500-1500	0.109
500-1500	10-100	0.362
	100-500	0.518
100-500	10-100	0.169

For number of employees, difference in perception between organization employing greater than 1500 employees with those employing 10-100 employees are clearly mentioned in Table 4.34. A part from overall lean conformance, difference between both these groups also emerged in the sub principle Eliminate waste as shown in Table 4.33.

4.9 Discussion of Results and important inferences about potentials and competitiveness for lean construction in Pakistan

The sample average mean of 54.18% as found out in section 4.4.3.1 indicates that the lean conformance practices in Pakistan neither has strong or weedy base. The philosophy of lean construction is only partially fulfilled in the Pakistan construction industry. The population mean also lies between 52.744% to 55.616% which confirms that the techniques used in lean construction are being partially followed and half understood. The mean average of 54.18% also indicates that in some form or the other, high or low,

understood or not, knowledge or ignorance, realized known benefits or unknown, the lean construction techniques are partially present in the industry.

The importance for the lean practices as found from the sample average mean is 83.74% and the population mean lies between 81.28% and 86.07%. These high percentages clearly specify that there is potential of further exploration of this technique in the industry as seeds of lean construction exist in the industry which is in the form of realization of the importance level of the principles of lean construction among the industry. The realization of the importance of the lean practices by the stakeholders shows that they fully know the benefits of the techniques and only require the opportunities to implement them.

Respondents giving high percentages to the importance of lean construction practices and low percent to the lean construction conformance show that the top and middle management of the construction industry know the benefits of the lean practices but could not implement them accurately because of the ignorance of tools and techniques as well as uncertainty for implementing lean practices.

These Figures possibly indicate that the construction organizations/firms in Pakistan though have a very bleak lean foundation but still the potential is there to implement it because of high importance level given to the lean sub principles and with the accomplishment of almost half of the lean conformance by the organizations.

One important thing observed during the survey is that the philosophy of lean construction is not known to most of the contractors, consultants and clients however the lean conformances of 54.18% are followed. Although it seems that this percentage is relatively less as far as lean thinking is concerned but positive point is, this much percentage is achieved even without the knowledge of lean construction and if the knowledge of lean construction tools and techniques are imparted, then this lean conformance percentage can be increased. Hence the potentials of increasing the lean conformances in Pakistan construction industry is also high if lean construction friendly environments are provided during and before construction by all the key stakeholders of the industry.

Regarding principles, Standardization (45.23%) is the one which yielded relatively lower values among the other four principles. Standardization is one of the main features of lean construction since it adopts the philosophy of keeping things consistent for the workers. A

clean, organized, and logical jobsite will lead to shorter cycle times and increased productivity but its value is lower than the sample mean of overall conformance. Standardization contains Visual Management (30.17%), Workplace Organization (57.9%) and Defined Work Processes (55.17%) sub-principles. The relative lowest value of standardization is due to the lowest values of the visual Management. Visual Management is defined by J.E. Diekmann (2003) as **"**posting of relevant information concerning schedule, cost, safety, and productivity about the job in a location that is convenient for all managers and crafts". Three questions were drafted as visual management 1,2,3 to check the visual management conformance. The conformance of visual management is only 30% which means that organizations are paying minimal attention in displaying the relevant information. Compared with the importance level, it is revealed that the same principle has lowest values and regarded relatively lowest among the others. This shows that the construction organizations in Pakistan regards it lesser important than other principles and this is the reason of its lowest lean conformance value.

Eliminate Waste (53.5%) is the 2nd lowest principle in lean conformance. Although it is the most important principle of the lean thinking but it is paid little attention in the industry. Although the awareness of eliminate waste is very much prevalent in the industry but the techniques to eliminate waste either don't exist or are quite conventional. Its sub principle, "optimize production system" yielded the percent fulfillment lower then 50%. This means that relatively lesser attention is given to work sequencing and balancing the crew. The importance level given to eliminate waste though is quite healthy (81.36%) yet is relatively 2nd lowest among the importance level for all the principles which gives some justification of its low conformance value too. Hence it can be concluded that construction industry in Pakistan knows the importance of eliminate waste but they want to achieve it by using the conventional techniques. This following of conventional techniques to reduce the wastes have not achieved the fruitful results so far.

The principle continuous improvement/Built in quality is in between all principles in the relative ranking of percent fulfillment i-e 56%. It is also among the topmost features of lean production and very much effective in the construction industry. The industry is paying partial attention to the preventive measures against the defects. Remedial actions are partially planned and most of the times the remedial actions are taken after the occurrence of the

defects but the importance level given to record keeping or remedial actions for halting the reoccurrence of the defects is the topmost in relative ranking i-e 89.77%. Companies own standards and production capacity constant are very moderately developed in form of metrics. However a concept of learning within the organization is at 63.79% which is at the top among all the sub principles of this particular principle. The passing of required information to the concerned is also quite high and passed immediately without losing much of the time. Continuous improvement/Built in quality has been regarded as the top most important principle with important level of 85.8%.

Cultural/People principle is second from the top in the relative ranking i-e 57.8% of fulfillment. Culture/People is included as a standard for lean construction because it lets the employee know that their involvement in the process is the reason that the company will be successful in the present and future. Although the overall percentages are not very healthy but percentages of its sub principle like people involvement (68.67%) shows that the organizations have considerably involved the people in the construction and takes them as integral members with due respect to their ideas but organizational commitments to accept new changes in improving the processes etc. is lacking and at only 48.25%. The training aspect of the employees regarding any new process development or change is also very much lacking in the industry as the sub principle "training" (44.25%) also have the 2nd lowest value of lean conformance after visual management. The relative 2nd position in percent fulfillment is justified by the importance level of 83.04% that too relatively 2nd from the top.

The principle Customer Focus (59.13%) though not has high percentage yet relatively regarded as the topmost fulfilled principle of lean thinking in Pakistan. The immediate response to the customer's requirements and changes are dealt effectively by immediately procuring the material or machine etc at lowest possible cost. Sub principle "Flexible resources" has relatively 2nd most fulfilled sub principle with 64.17 percent fulfillment. However 2nd sub principle of this principle i-e "optimize value" is at 51.58% and relatively in between all the sub principles. The values, changes, requirements of customers are understood partially. Importance level in percentage for Customer focus is 82.52% which is quite healthy and considered to be very effective in achieving the objectives of the project.

The lean conformances and importance level among different categories of the organization as well as respondents are calculated to draw necessary conclusions and determining the

potentials and competitiveness of the lean construction with in the categories and groups defined. The results of each the attributes are discussed below:

4.9.1 Organizational and Respondents Attributes

No major difference is found between all the groups within the all the attributes whether organizational or respondents related, except for the groups within the organizational attributes of project cost usually undertaken and number of employees. The organizations/firms which undertake projects of greater cost perform better because of relatively greater mean value as compared to the organizations undertaking projects of relatively lower cost. Similarly the organizations/firm which usually employ more number of employees perform relatively better lean practices as compared to the one which employ less employees

Hence it can be concluded that the relatively bigger organizations and firms perform better lean practices as compared to the smaller ones.

No major conclusions can be drawn for importance level as all groups with in respective attribute have similar perception of importance for the lean practices and it can be concluded that all groups/categories within respective attribute have graded the lean practices as equally important.

Chapter 5

POTENTIALS, COMPETITIVENESS AND IMPLEMENTING STRATEGIES

5.1 Potential and Competitiveness

Potentials and competitiveness for the lean construction is judged through the two factors i-e lean conformance and the importance of the lean principles with in the Pakistan construction industry. To find the potential, one has to perform acceptability and feasibility tests for the adoption of the new philosophy. The acceptability test is used for finding whether this new philosophy will gain crucial support from the people it needs to or whether it will lead to opposition or criticism. The general management theorists (Carnall, 1990) argue that people will accept new philosophies if they accept its principles and believe that they are true. Acceptability test is carried out by taking the importance for the principles from the respondents. Although it is very difficult to conduct the feasibility study which means, finding the capacity of an organization to carry out/perform the tools and techniques mentioned in the new philosophy but to make some inference the current lean conformance level as determined earlier is taken as the capacity for undertaking the lean philosophy. Numerically the potential is calculated by multiplying the importance level with the lean conformance for each sub principle to assess the potential. The results show that Pakistan construction industry has moderate potential for lean construction. The scale used to interpret the potential is given in Table 5.1. The potentials in Pakistan construction industry for lean construction are shown in Table 5.2.

Table 5.1: Scale for Assessing the Potential

< 14 %	Very Low
15-28 %	Low
29-42 %	Moderately low
43-56 %	Moderate
57-70 %	Moderately High
71-84 %	High
>84 %	Very High

Table 5.2: Potential- Sub principle

Sub Principles	**Conformance**	**Importance**	**Aggregate**	**Potential for implementing**
People involvement	0.68	0.8429	0.573	**Moderately high**
Organization commitment	0.4827	0.816	0.393	**Moderately low**
Training	0.4425	0.8125	0.359	**Moderately low**
Metrics	0.5114	0.87	0.444	**Moderate**
Error proofing	0.5625	0.8304	0.467	**Moderate**
Response to defects	0.5141	0.8639	0.444	**Moderate**
Organizational learning	0.6379	0.862	0.549	**Moderate**
Flexible resources	0.6417	0.8429	0.540	**Moderate**
Optimize value	0.5158	0.798	0.411	**Moderately Low**

Table 5.2: Potential- Sub principle- Continued

Sub Principles	Conformance	Importance	Aggregate	Potential for implementing
Supply chain management	0.6386	0.8333	0.532	**Moderate**
Optimize production system	0.4856	0.774	0.374	**Moderately Low**
Reduce process cycle time	0.495	0.8204	0.406	**Moderately Low**
Optimize work content	0.5057	0.839	0.424	**Moderate Low**
Visual management	0.2643	0.6609	0.174	**Low**
Work organization	0.577	0.81	0.467	**Moderate**
Defined work process	0.5517	0.859	0.473	**Moderate**
Overall Potential			**0.447**	**Moderate**

5.1.1 Cultural/People

The lean conformance and the importance level for this principle is 57.8% and 85.52% respectively. To find the potential and competitiveness, sub principles of this principle are discussed individually below:

People Involvement (Potential-Moderately high)

The involvement of people is given due regards in the industry and considered very important in the execution phase of the project. The ideas as shared by the people for improvement of work processes are given healthy weightages (73.85%). Similarly people are considered integral members with percent fulfillment of 65.51%. Hence the seeds for effectively implementing the sub principle of people involvement already sown in the industry. The

healthy lean percent fulfillment along with a very high importance level given to this sub principle i-e 84.29% by the respondents clearly indicates that there is a moderately high potential for implementing this sub principle in true spirit.

Organizational Commitment (Potential-Moderately low)

Although the importance level is comparatively high to pass the acceptability test but the capacity is only partial for implementing this sub principle. A lot needs to be done in this respect in terms of changing the psychology of the top management to accept the lean construction. Potentials for implementation are there but moderately low because of satisfied acceptability level but top management needs to be well awared for implementing lean construction.

Training (Potential-Moderately low)

Relatively high values of importance level clearly shows that the industry accepts this principle but the potentials to adopt it is pushed backward because of lack of the capacity or conformance level for this principle. This principle can only be accepted by those organizations which hire the employees' either permanently or for a longer duration. Public/autonomous organizations in Pakistan have greater potential of implementing it but at the moment very few firms/companies have the potentials for spending on this sub principle.

5.1.2 Continuous Improvement/Built in Quality

(Conformance - 56%, Importance Level 85.8%). Sub Principles are discussed individually as follows:

Metrics (Potential-Moderate)

The importance level is relatively highest among all the 16 sub principles. The conformance level is just more than 50%. This means that moderate potential is there but needs a lot of work in enhancing the capacity for knowing the organizations to set their own standards in some recordable form which can be used in future for measuring their own performances. The factual position of the company's worth can be known by having a glance at the metrics. Regular updating of the metrics must be carried out. Bigger companies have higher potentials for implementing this because of the resources available to them.

Error Proofing (Potential-Moderate)

The conformance level is above the average overall lean conformance value and the importance level is also quite high. This sub principle has moderate potential to be implemented in Pakistan because every contractor, consultant and client have realized the problems associated with the defects and wants to get rid of it prior to its occurrence. If the techniques of lean construction are properly taught to them then they will get the benefits after its implementation.

Response to defects (Potential-Moderate)

Very high rating is given to the importance of this sub principle but the conformance level is below the average value. This sub principle will have moderate potential to be implemented because defects in the industry are common to occur and cause financial and time losses which has been realized by the industry and that's why given high importance level to it. Only learning and implementing of this lean technique is required. Development of culture for zero defects have to be inculcated which is very much lacking in the industry. **Organizational learning**. (Potential-Moderate)

Satisfactory conformance level and high importance given to this sub principle clearly shows that it has the potential of being implemented. Already the industry is familiar with this sub principle and implementing it at 63.79%.

5.1.3 Customer Focus

(Conformance - 59.13%, Importance - 85.52%) Details of the sub principles are:

Flexible Resources (Potential-Moderate)

The acceptability level is quite high in terms of importance as well as the conformance level which is also satisfactory. The organizations/firms have already realized this aspect and try to change direction with the changing requirements of the customer instead of changing the actual resources too much.. Hence there is a potential of further development of this sub principle by proper training and awareness programs.

Optimizing Value (Potential-Moderately low)

The relative satisfactory value of importance level as recognized by the respondents dictate that the acceptability for this sub principle is higher among the industry but the conformance level is below the average. The organizations have to learn this technique and increase the coordination level with the customers to extract their value/requirements of the project. The moderately low potential is there and a lot of work is required to get the expertise on the sub principle.

5.1.4 Eliminate Waste

(Conformance - 53.5%, Importance - 81.36%). Details of the sub Principles are:

Supply Chain Management (Potential-Moderate)

The firms/organizations are maintaining satisfactory conformances in terms of material management and moderately ensure the minimization of material wastage. The comparatively large firms that are undertaking >500 M cost projects are performing relatively better conformances. Whereas in terms of operational time and number of employees, comparatively larger firms/organizations are conforming better as compared to others. Potential is present for implementing this sub principle for minimizing the wastages in material both in handling, idling and transporting but the biggest hindrances in its implementation are the rapid market prices fluctuations and non-trust worthy suppliers. The firms/organizations have the foundation for this sub principle but all they need is expertise which comes from training, knowledge and awareness programs. Moreover stability in the market and awareness programs of suppliers also needs to be worked upon to greater level.

Optimize Production System (Potential-Moderately low)

The relative value of conformance is much lower than the average. Moreover the importance level is also relatively lower as compared to other sub principles. Hence there is not a healthy potential for immediately implementing this sub principle. However with more realization, awareness and seeing the comparative advantages of this sub principle if implemented by any firm, the potential may be increased.

Reduce Process Cycle (Potential-Moderately low)

Acceptability level is quite high, as regarded important sub principle, by the respondents. However the conformance level is quite below the average. The potentials for implementation at the present moment are not healthy because to implement this sub principle the education level of the desired persons should be more. Evaluation of master plans, reverse phase scheduling, look ahead plans and weekly plans along with first run studies and risk management techniques all require the expert and educated staff which is lacking in the industry at the moment. Top management strong interferences in this regard are essential for improving the potentials for implementing it. Even the firms/organization undertaking the projects of cost >500 M could not be able to implement this sub principle effectively.

Optimize Work Content (Potential-Moderately low)

The realization of the importance of this sub principle is quite high and the conformance level is almost 50% still below the average. The realization of this aspect by the consultants and clients is very important for the implementation of this principle which is at the moment lacking i-e 42% and 48% respectively. But the moderately low potentials for implementing this sub principle are still there because of the reduction in the time and closely monitored processes. The recent introduction of pre stressed concreting and standardization especially in the field of bridges and underpasses in Pakistan encouraged the potentials for implementing this sub principle.

5.1.5 Standardization

(Conformance - 45.23%, Importance - 76.02%). Details of the sub principles are:

Visual Management (Potential-Low)

Very low conformance and relatively lowest importance level among all, dictates that the construction industry in Pakistan is hesitant in implementing this principle. This aspect at the moment has very low potential of implementing in Pakistan unless very detailed realization programs regarding benefits of this sub principles, training and due emphasis is not given by the top management to this aspect. Neither smaller nor relatively larger firms are

implementing this technique as none of the conformance touches 50% by any attribute, category or group.

Work Place Organization (Potential-Moderate)

The conformance level is more than the average and importance level is also quite healthy for this sub principle. Moderate potential exists for the implementation of this sub principle as the firms/organizations have realized the importance of proper 5 ‘S i-e separate/Scrap, straighten, scrub, sustain, and systematize.

Defined Work Processes (Potential-Moderate)

The relative high value of importance indicates the acceptability of this sub principle by the respondents. The conformance level is just close to the average value. This shows that the potential for implementation is there but more realization, training and awareness programs are needed to effectively employ it. At the moment the more common and repetitive processes are defined at foremen level but no documentation is carried out for the defined critical processes.

5.2 Implementing Strategies

As far as implementing strategies are concerned, competitive strategy is mostly adopted by the business world whenever a new change in implementation methodology is required to be introduced.

5.2.1 Construction as a Competitive Strategy

Competition among the construction industry in Pakistan is too much and is increasing day by day. There are more than 32000 contractors and 380 consultants which are so far registered with the Pakistan Engineering Council (Pakistan Engineering Council official web site, www.pec.org.pk/downloads.aspx). However quite more than the same number of contractors and consultants must be waiting for the registration or not have applied for it. The huge number of contractors and consultants related firms clearly demonstrates the high competitiveness level among themselves in future. In the longer run the survival lies with those who deliver the quality projects at minimum time and cost. The lean construction approach will provide that competitive edge to those firms which employ this philosophy. Implementing Strategies for Pakistan

After realizing that Pakistan Construction industry has the potential to absorb certain sub principles of lean construction with ease and few sub principle require a concentrated effort and commitment from top, middle and lower management to be implemented. However some principles are very hard to implement in the Pakistani environment and require the institutional level support a part from the commitment by all the management tiers. The implementing strategies will be discussed in this section keeping in view the peculiar Pakistan environment.

5.2.2 Inclination toward lean construction

The first step for implementing the lean construction is to mentally incline the industry towards the lean thinking. To achieve this inclination, few recommendations are as under:

a. **Awareness**: It is already established that construction industry personals consider the lean sub principles as important in achieving the objectives of the project in efficient/best manner. The first step to inculcate the lean thinking is to increase the level of awareness for lean construction. Workshops/Seminars, training sessions, advertisements, special lectures at institutional level etc. showing the benefits and gains of lean construction in the countries which has been implementing this philosophy be held at regular intervals. The awareness programs will act as a starter activity in tilting the minds of the key stake holders toward the lean construction. Institutions can play a vital role in this regard as it is producing the young engineers as well as has the capability of arranging workshops/seminars and research studies in this field. The campaigns should be targeted at clients, consultants, contractors, suppliers and subcontractors informing them of their roles within each stage of the project.

b. **Commitment by the top management**: It is not possible for any organization to adopt a new technique without the ample support and personnel commitment by the top management. Commitment comes from the belief and belief on lean construction at the moment among the top management is very uncertain as far as practical implementation is concerned. The obvious reasons are lack of knowledge about the lean construction in specific and project management in general and non-practice of lean construction by any agency. Top management should be encouraged through seminars/workshops and special motivational lectures at their construction sites by the support of Pakistan Engineering Council. Execution of one or more smaller activities

by employing the lean construction is a good option to increase the confidence level of the top management. But this can be done only through the support of Pakistan Engineering Council.

c. **Government Support**. Certain steps can be taken at the Government level to promote this philosophy so that at least it takes a start. Planning commission of Pakistan can impose lean construction on few projects to check its adequacy in Pakistan. An institution can be given the task of providing supervisory consultancy at the initial stages. Once few projects get completed using the lean construction tools and techniques, the author is quite sure that an immediate boom in adoption of this philosophy among the construction companies will be visible because of its many benefits which are the need of the moment for construction industry of Pakistan. In this regard some international firm can be hired to execute a project in Pakistan using lean construction which provides path way towards the lean construction by successful implementation.

d. **Increased Research**. The Institutions should increase the amount of research in this field. With the research, the person doing the research visits and meets so many officials and management staff and discusses its research. In this way extensive awareness for the lean construction emerges. As an example the author managed to get 92 responses means at least these 92 respondents now have some picture of the lean construction. And most of the respondents after reading the questions easily understood them. So if the level of research in this field increases, the goals of awareness and more authenticity on lean construction will be simultaneously achieved.

e. **Role of clients**. Major clients can play an important role in tilting the contractors and the consultants towards the lean implementation. Major clients at federal level like National highway authority, Capital Development Authority, Military Engineering Service etc and at provincial levels like Provincial/City development authorities can influence the contractors and consultants toward adopting this philosophy in few selected projects to check the adequacy. The special seminars/workshops be conducted for these clients to change their conventional thinking toward this new change.

f. **Education**. Institutions can play a vital role in imparting the basic knowledge of lean construction to the under graduates and detail knowledge in the Master programs. Courses on lean construction should be offered to post graduates to increase the level of knowledge for this philosophy.

g. **Partnering Concept**. Lean philosophy cannot be operated in isolation. Every agency involved have equal benefits in the project. This introduces a kind of concept of partnering between Clients, consultants and contractors and similarly between contractors, subcontractors and suppliers. Each parties when realizes that any wrong act from their respective side will ultimately results in compromising the benefit to them also, will help in implementing the lean philosophy to great extent. Every party in this way considers the project as owned by them. They will work for the betterment and benefit of the project rather their own, which ultimately results in favor of every one.

h. **Pilot project**. A pilot project must be undertaken by employing the lean construction tools and techniques to see the efficacy of this philosophy in the Pakistan. Either some educational institution or any major Client should take this challenging initiative. The day to day progress in terms of cost and time should be publicized and shown to everybody so that everybody gets the visibility of the efficiency of this philosophy. Special visits of the top officials from the Government as well as private sector be arranged during the construction. In this way the uncertainties in this philosophy because of non-execution be reduced among the construction industrial stakeholders.

5.2.3 Implementing the lean construction by the organizations in project delivery

Once the awareness for lean construction rises to a level that organizations make up their mind for implementing the lean construction in their projects, then few strategies for implementing this philosophy by the organizations are discussed below:

a. **Technical and behavioral Training**: The first step towards the effective implementation of lean construction process is training (Othman, 2011). The training is necessary for all the key stakeholders of the organization taking part in the project delivery. The training is essential for developing the skills for lean construction. This is applicable to project team members, top management, and anyone that plays a role in the implementation effort. The lack of skills makes top management anxious, because they are spending money, time, and effort and may not be seeing the

expected results. Skills are inculcated in the selected project team through training. Technical training promotes competency, and behavioral development fosters commitment. More emphasis should be laid on the behavioral development to ensure commitment for the lean construction implementation. In lean construction the behavioral commitment is key to success. Another important way of inducting behavioral commitment toward lean is by defining some methods of measuring the performance as Goldratt et al. (1992) states: 'Tell me how you are going to measure me, and I'll tell you how I will behave'.

b. **Vision:** Vision statement before the start of the project must be clearly set a side by the top management which sets the complete frame work for the mission, objectives, and strategies for the implementation effort of lean philosophy at the project level. Everyone at least up to foreman level and even to skilled manpower must know the vision of the top management of what is required to be achieved and how it will be achieved and what all successes will be accomplished at the end by employing the lean construction.. The top management in full collaboration with the project team formulates the implementing strategy. At this stage, it is common to get questions/comments challenging the need to do something different, the need to change: Why are we doing this? Why me? Why in my project? Why aren't my efforts appreciated – I delivered great profits in my last projects?

c. **Incentive:** Some kind of effective incentive scheme should be adopted to create and develop the commitment and motivation for the project team which is a key in implementing the lean construction philosophy. The incentives should be carefully analyzed as few project team members require the monetary and few require the recognition type of incentives. Increased salaries for the workers and skilled manpower participating in the implementation of the lean techniques at the initial stages may boost the participants in Pakistani Culture.

d. Display of short time successes. A mechanism should be evolved to show the project teams what they have achieved so far by comparing the progresses in terms of quality, cost and time with the old/conventional methods of delivery. These should be frequently displayed/discussed may be twice a week in the initial stage to raise the morale and causing self-containment among the project teams. This will also increase the beliefs on this new change adopted.

e. **Commitment by the top management.** Top management should provide full commitment for the change effort to be successful. They should extend full support in terms of resources so that project team realizes the importance of this change. Frequent interaction with the team and motivational talks along with some praise can be very useful in raising the morale and standards of the team. The lean philosophies in Pakistan will only start from the top to the bottom of the company and this arrangement is essential to success. If management fails to exercise leadership, the degree of commitment from lower levels of the organization is at risk.

f. **Find a change agent**: Since this technique at the moment is quite unfamiliar among the top, middle and lower management. To start with, a trained change agent or team having the expertise in lean construction can be hired to impart training as well supervise the lean efforts on the project as well as in offices. This is a person who makes things happen.

g. **Reliable suppliers and sub-contractors**: Lean production success mainly depends on the team effort and if any one link is missing the whole lean effort can jeopardize. Suppliers are important link in the chain and the quality and availability of material is totally dependant on the suppliers. Organization should select the most reliable suppliers for this purpose. Training of the suppliers and sub-contractors be also conducted. Rather the selection of suppliers and sub-contractors be made on the commitment of implementing the lean philosophy. Special motivational lectures and procedural issues be presented to them time and again. No actions should be planned in isolation. The suppliers and sub-contractors inputs should be taken in planning stage. This emphasizes that subcontractors and suppliers should be selected well in advance before the planning sessions.

h. **Costumer in mind:** All the efforts directed to lean production must include the costumer, the ultimate judge of a firm's efficiency. The modern organization must know its customers, know their needs, and communicate with them constantly.

i. **Gradual Implementation**: Organizations who made up their mind for implementing the lean thinking must implement the techniques gradually. Immediately changing the whole culture of the organization will not be fruitful. Initially it must start at a smaller scale alongside the old/conventional method. The lean teams will operate in that project; learn the techniques through practical handling and experiments with the

guidance of the experts before starting a complete project. The conventional/old technique should also be carried along and gradually be completely finished. The breakeven point where the organization completely discard the old/conventional techniques and fully operate with the lean philosophy must be carefully planned by closely monitoring the successes and failures of the lean philosophy. There might be a possibility that despite all the efforts, the organization could not be able to implement the lean philosophy or this philosophy couldn't be blended with the organizations objectives. The rate of change is the most important lean metric.

j. **Situational leadership by project manager**: Project manager role in implementing the lean thinking is vital and truly displays his leadership qualities. The project manager should analyze his complete team and should know which of the team members are in favor of the change and which are resisting it. The resistance should always be welcomed but with the reason of improvement. They should closely interact with the team members and try to motivate the members who are resisting with the reasons. The lean advisor hired for this can provide a great support to the project manager in this regard. Project manager should closely monitor all the processes, provide his input, measure the performance and analyze the performances to see where lays the room for improvement. Gradually he should inculcate this aspect to every team member so that a stage arise when every member of the project team can take own initiative in the determination of improvements by themselves. Project manager should be easily approachable and is the one who has to initially plan all the processes as per the lean philosophy with due consultation with the project team. Every pros and cons of the processes should be analyzed and critics on the actions be encouraged to get the maximum output.

k. **Client Support**: The clients have to support the executing agencies in all the aspect of the lean implementation. Initially the clients are the one who should hire the lean advisors/consultants who supervise the work, make plans and impart training to the project team. The commitment by the clients will be key to the success of lean implementation. They should extend their full support and commitment at every stage of the work. They should regularly attend the meetings with the open minds to accept what is best for the project as a whole. They should clearly define their values, objectives and requirements to the implementing teams in full coordination with

them. They should think themselves as part of the project team and not a controlling organization.

l. **Consultants Role**: The design of the complete project must be supportive to the lean thinking. The standardization of work items like pre fabrication, repetitive items, precast/pre stressed panels etc should be incorporated in the design process. Consultants are the one who can play an influencing role in convincing the clients towards the lean supportive designs by duly fulfilling the values and requirements of the Client in a befitting manner.

m. **Implementing the lean tools and techniques fully**: All the tools and techniques should be imparted fully and completely as these are linked to each other in a chain. Any link missing will eventually lead to the reduced efficiency of the lean thinking. The organizations must implement the lean philosophy when they consider that all of their teams are now trained, committed, acquired the requisite knowledge and mentally accepting the lean thinking as effective one. The improvement will be made in the implementation process once the change system starts working.

n. **Induction of Permanent Teams**: Induction of permanent teams at the moment is very difficult in the private sectors because of the uncertainty of getting the projects in the competitive environment. The larger firms and Government bodies can afford to have the permanent teams but at the moment the smaller or even medium firms cannot. These smaller and medium firms can have a phased program in permanent induction. They can initially rely on their most sincere team workers who are working with them since long. Amalgamation of permanent staff and workers with temporary staff and workers can be employed at the initial stage till the efficacy of the system. Once the employments are permanent the training for multi skilled culture can be imparted.

The implementation of lean production demands a formal strategy and the change in almost every aspect of project and company management. Steps recommended for implementation are only the guides but cannot be the final answer because change at the mental model level is a developmental process. Every principle obsessed action will disclose new hidden opportunities because people simply could not think in ways that made the change possible. Thinking causes action, action causes deep learning, and learning causes new thinking.

Chapter 6

CONCLUSION AND RECOMMENDATIONS

6.1 Important Conclusions

1) The Construction industry of Pakistan is unaware of lean construction philosophy, its principles and its implementing tools and techniques.
2) The sample average mean of 54.18% shows that Pakistan Construction industry does not have a strong Lean construction base.
3) The populations mean also lies between 52.744% to 55.616% which confirms that the techniques used in lean construction are being partially followed and half understood.
4) The mean average of 54.18% also indicates that in some form or the other, high or low, understood or not, knowledge or ignorance, realized known benefits or unknown, the lean construction techniques are partially present in the industry.
5) The importance for the lean practices as found from the sample average mean is 83.74% and the population mean lies between 81.28% and 86.07%.
6) These high percentages of importance level and partial implementation of lean practices shows that moderate potential is available in Pakistan construction industry for implementing lean construction
7) The lean construction practices will offer competitive advantages to the followers because of increased quality and relatively lower completion cost and time it offers for the project.
8) Industry is paying minimal attention for keeping the employees updated on the latest project based informations as well as managing the wastes.
9) Risk management is seldom carried out within the projects especially for the individual activities.
10) There is no concept of multi skilled labor culture in the industry.
11) Potential for implementing visual management, multi skilled culture and training with in organization is low.

12) Potential of further developments of lean construction increases with the financial capability of the organizations to undertake the project. More financial capable Organization performed relatively better in lean practices
13) The greater the number of employees the better are the lean practices. The Firm/Organizations employing 1500 or greater employees performed relatively better.
14) No major conclusions can be drawn with in groups of all other attributes because of very close values.

6.2 Recommendations

The Pakistan construction industry though retains many pros and cons but in particular have very competitive nature. There are abundance of contractors/consultants companies for executing the limited number of construction projects available. Hence competition among the companies is very high. It was observed that the all the clients, contractors and even consultants had very little or no idea about the terminologies of lean construction yet, they are performing few lean practices in bits and pieces. Few recommendations are made at the end of the study.

6.2.1 Future Research

First of all, few recommendations for the future researches are:

1) A case study on an existing/ongoing project be carried out to compare expected lean results with the actual implemented results in terms of time, cost and quality:
2) Study of all type of wastes in construction industry of Pakistan and suggesting methods to eradicate these wastes by employing lean construction philosophy.
3) The same research but to the level of supervisors, foremen and workers.

6.2.2 General Recommendations for organizations/Firms

The general recommendations for the organizations/firms for moving towards lean or transforming their organizations/firms approach in favor of lean construction are as under:-

1) **Technical and behavioral Training**
    a. More emphasis should be laid on the behavioral development to ensure commitment for the lean construction implementation

b. Another important way of inducting behavioral commitment toward lean is by defining some methods of measuring the performance.

2) **Incentive**

Some kind of effective incentive scheme should be adopted to create and develop the commitment and motivation for the project team which is a key in implementing the lean construction philosophy.

3) **Find a change agent**

Since this technique at the moment is quite unfamiliar among the top, middle and lower management. To start with, a trained change agent or team having the expertise in lean construction can be hired to impart training as well supervise the lean efforts on the project as well as in offices.

4) **Reliable suppliers and sub contractors**

a. Organization should select the most reliable suppliers.

b. Training of the suppliers and sub contractors be also conducted.

c. The selection of suppliers and sub contractors be made on the commitment of implementing the lean philosophy. Special motivational lectures and procedural issues be presented to them time and again.

5) **Consultants Role**

The design of the complete project must be supportive to the lean thinking. The standardization of work items like pre fabrication, repetitive items, precast/pre stressed panels etc should be incorporated in the design process.

6) **Induction of Permanent Teams**

a. Although it is difficult to be implemented at the moment for small and Medium Firms. However a phased program can be help ful in inducting permanent teams. They can initially rely on their most sincere team workers who are working with them since long. Amalgamation of permanent staff and workers with temporary staff and workers can be employed at the initial stage till the efficacy of the system

b. Once the employments are permanent, the training for multi skilled culture can be imparted.

6.2.3 General Recommendations for Construction Industry

The general recommendations for implementing the lean construction in the construction industry of Pakistan are as follows:-

1) **Awareness**

   The first step to inculcate the lean thinking is to increase the level of awareness for lean construction. Workshops/Seminars, training sessions, advertisements, special lectures at institutional level etc showing the benefits and gains of lean construction in the countries which has been implementing this philosophy be held at regular intervals.

2) **Commitment by the top management**

   Top management should be encouraged through seminars/workshops and special motivational lectures at their construction sites by the support of Pakistan Engineering Council. Execution of one or more smaller activities by employing the lean construction is a good option to increase the confidence level of the top management

3) **Increased Research**

   The Institutions should increase the amount of research in this field. With the research, the person doing the research visits and meets so many officials and management staff and discusses its research. In this way extensive awareness for the lean construction emerges

4) **Education**

   Institutions can play a vital role in imparting the basic knowledge of lean construction to the under graduates and detail knowledge in the Master programs. Courses on lean construction should be offered to post graduates to increase the level of knowledge for this philosophy

5) **Government Support**

   a. The Ministry of Works and Planning commission can impose lean construction on few projects to check its adequacy in Pakistan.
   b. An institution can be given the task of providing supervisory consultancy at the initial stages.

c. Some international firm can be hired to execute a project in Pakistan using lean construction which provides path way towards the lean construction by successful implementation

d. A pilot project must be undertaken by employing the lean construction tools and techniques to see the efficacy of this philosophy in the Pakistan.

e. Either some educational institution or any major Client should take this challenging initiative through Pakistan Engineering Council.

6) **Role of clients**

a. Major clients at federal level like National highway authority, Capital Development Authority, Military Engineering Service etc and at provincial levels like Provincial/City development authorities can influence the contractors and consultants toward adopting this philosophy in few selected projects to check the adequacy.

b. Special seminars/workshops be conducted for these clients to change their conventional thinking toward this new change by the support of Pakistan Engineering Council

7) More Financial Strong Firms/Organization

Initially the introduction of lean construction can be started with the larger organizations (in terms of project cost usually undertaken and number of employees employed) as they were found to have comparatively higher lean conformance values from others for the principles/sub principles of the lean thinking. At this moment, they can be considered as more ready to apply the lean techniques/tools in comparison with the rest.

6.3 Conclusion

Lean manufacturing has brought the revolution in manufacturing industry and contributed a lot in the overall efficiency and success of this industry. In parallel the construction industry remained backward and displayed numerous wasteful practices which resulted into wastes unacceptable in this modern era of highly competitive environments. As a result, lean construction mostly inspired from lean thinking was introduced in early nineties. Lean construction philosophy is different from traditional construction in the way that it incorporates the transformation, flow and value in a project whereas traditional construction only stresses upon the transformation. The emerging popularity of lean construction can be

seen as most of the developing countries are rapidly transforming into lean because of the abundance of benefits it offers in terms of time, cost, quality and safety.

In Pakistan, the construction industry is still backward and as a result many wastes are inherent in the industry which results into most of the projects being delayed, experience cost overruns and quality issues. Implementation of lean construction is the need of Pakistan construction industry to overcome these problems. At present the Industry has no know how about the lean construction but potential is there for the adoption of this philosophy because of high importance given to this philosophy by the key construction personalities in Pakistan. Moreover even without the knowledge of lean construction, few lean construction practices are being followed. Implementation and further development of lean construction in Pakistan requires a lot of efforts at all level. The commitment, awareness, training, education and belief in lean construction are the initial steps to be undertaken at government as well as educational institutional levels.

Reduction in number of wasteful practices, improvement in the management styles, reduced timings, cost control, quality improvement, safety performances are the fundamental needs of the Pakistan construction. In this highly competitive environment only those organizations/companies/firms will survive that align themselves with the best skills available in the market. These fundamentals needs and competitive advantages can be achieved by adopting the lean construction philosophy.

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Appendix 1

DESCRIPTION OF PRINCIPLES AND SUB PRINCIPLES OF LEAN CONSTRUCTION

(J.E. DIEKMANN, 2003)

Cultural/People: This principle aims at letting the each and every employ of the organization/Firm to understand that their involvement in every process is the key to the success of their organization/Firm in the ongoing as well as all future assignments. All the lean behavior has to be adhered by them because without their self-participation, the lean construction cannot reach its full potential. Lean behavior always starts from top management to the field laborer duly incorporating every member in the chain. For this principle, there are three sub principles. Details are as under for each sub principle:

a. **People Involvement**: It is the degree of authoritativeness, understanding, obligation and commitment of people for achieving the goals of reducing the waste and continuous improvement for the company or project.
b. **Organizational commitment**: it shows that all levels of management and supervisor staff are fully committed to the principles and practices of lean execution and continuous improvement. They want and committed to bring/accept the change for the Organization/Firm's improvement
c. **Training**: It is defined as the level to which project teams are educated to implement a designated task to finish specific activities. This sub-principle takes into account of how regularly employees are trained along with all the necessary documentation of imparted training and the overall training plans.

Continuous Improvement/Build-in-Quality: This sub principle appends to the concept that quality should be inherent in a project, and that the mission to attain this level of near perfection should be an on-going and continuous pursuit. For this principle, there are four sub principles. Details are as under for each sub principle:

a. **Metrics**: It deals with the notion that organizations/ firms will keep on developing the standardized measures as per their best capability and will use them to supervise and improve all project processes. These should be consistent and understood by all the employees. There are many possibilities for measurement in construction that could be developed and used as a tool to improve the overall process.

b. Response to defects: This sub principle ensures the effective resolution of problems and then recording those for future compliance. As a concept, as early a problem is identified and resolved, lesser will be the rework and wastes.

c. **Error Proofing**: It deals with taking proactive measures to eradicate improper assembly or installation.

d. **Organization Learning**: It is the absorption, retention, and transfer of knowledge throughout the company to enhance continuous process improvement. It should be kept in mind that Improvement is endless and eternal.

Customer Focus: It aims at reducing the possibilities of rework due to changes by the customers. It is only possible if the requirements of the customers are fully understood from the beginning. The changes are to be dealt abruptly. For this principle, there are two sub principles. Details are as under for each sub principle.

a. **Flexible resources**: It works on the principle that actual resources should not be flexible whenever any change from customer's side is encountered but the organization/firms should change their direction to meet the customer needs without losing much money and time. How early they adapt to customer's requirements and change, better will be execution in most efficient way. It includes immediate ordering of necessary materials and equipment, the skill to quickly inform the personnel of the change in scope and help them adapt to the new requirements. It is not the actual resources that need to be flexible, but the company that needs to have the ability to change directions for the customer without losing much time or money

b. **Optimize Value**: It deals with the immediate understanding of the complete customer requirements. If the requirements/values of the customer is clear, it can plan accordingly and meet these needs in the most effective manner.

Eliminate Waste: Lean principles aim at reducing the wastes all the time. It is one of the main principles of lean construction. Every member of the organization should always in the hunt of activities that are producing the waste. For this principle, there are four sub principles. Details are as under for each sub principle:

a. **Supply Chain Management**: It inculcates the aspects of just-in-time delivery and minimizing the number of times materials are moved or relocated
b. **Optimize Production System**: The main purpose of this sub principle is to function on the ideas of work sequencing, crew balancing and WIP reduction.
c. **Reduce Process Cycle Time**: It ensures that the flow of work should remain continuous all the time and all-out effort should be made in maintaining the flow.
d. **Optimize Work Content**: It deal with the concerns associated with the impact of design on the potential to achieve lean performance. It considers standardization, repetition and preassembly and pre-fabrication.

Standardization: It is aimed at keeping things consistent for the workers. A clean, organized, and logical jobsite will lead to shorter cycle times and increased productivity. For this principle, there are three sub principles. Details are as under for each sub principle

a. **Visual Management**: Posting of pertinent information relating to schedule, cost, safety, and productivity about the work in a location that is convenient for all managers and crafts, are the aims of this sub principle.
b. **Workplace Organization**: it encompasses that the material on the work site, resources and all type of equipment/ tools required on the site must be organized and structured for efficient project execution. This sub-principle

also encompasses the 5s's (Separate/Scrap, Straighten, Scrub, Sustain, and Systematize)

Defined Work Processes: It aims at knowing all the critical processes on the way to final delivery and documenting it in such a way that they are known to all the employees in the respective work site.

Appendix 2

THE QUESTIONNAIRE

Respondents

(Please TICK any column in front of the information asked in left most column below)

1. **Name**						
2. **Firm/Organization/company Name with appointment**						
3. Projects usually undertaken cost (Millions)	0-100 M	100-200 M	200-300M	300-400 M	400-500 M	>500 M
4. **Profession**	Client	Architect	Consultant	Contractor	Academia	others
5. Education	Bachelor's Degree	Degree Master	Degree Doctorate	Diploma Holder	Others	
6. Position	Project Manager	Site Engineer	Contract Administrator	Designer	Academia	Others

7. Level of Experience (years)	0-5	5-10	10-15	15-20	>20	
8. Operational time since its foundation (years)	0-5	5-10	10-15	15-20	>20	N/A
9. Average number of employees (Numbers)	10-100	100-500	500-1500	>1500	N/A	
10. Major Clients	Public	Private	Both Public and Private		N/A	
11. Geographical operation Location	All abroad	Spread in the country and Abroad	All in the Country		N/A	

Pertinent to the Research

Tick any column after reading the statement. A question below every statement is given to see the general aptitude of the respondents towards the statement above.

Principles of Lean Construction

1ST Principle of Lean Construction	Cultural/People

People Involvement 1(Please TICK any column in front of the respective statement on the left)

12. Employees openly and freely discuss their views for the improvement of organization's processes	Never	Seldom	Sometimes	Often	Almost Always	N/A
13. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

People Involvement 2

14. Employees are considered an integral member of improving the Firms like planning activities, gives suggestions to improve the operations etc	Never	Seldom	Sometimes	Often	Almost Always	N/A
15. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in			Hardly ever	Sometimes		Most of the times

efficient/best manner			

People Involvement 3

16. Employees viewpoints/suggestions for improvement and execution are given due consideration by the top management	Never	Seldom	Sometimes	Often	Almost Always	N/A
17. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner			Hardly ever	Sometimes		Most of the times

Organizational commitment 1(Please TICK any column in front of the respective statement)

18. Upper-level management endeavors to change the firm's culture for effectiveness	Never	Seldom	Sometimes	Often	Almost Always	N/A
19. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner			Hardly ever	Sometimes	Most of the times	

Organizational commitment 2

20. Management and supervisory staff have developed a mechanism for keep them updated with new changes in construction management and give enough weightage to them	Never	Seldom	Sometimes	Often	Almost Always	N/A
21. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever	Sometimes	Most of the times			

Training

22. The firm introduces such activities which enables the employees to gain new skills that are necessary to meet changing needs of the firm	Never	Seldom	Sometimes	Often	Almost Always	N/A
23. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in	Hardly ever	Sometimes	Most of the times			

efficient/best manner			

2nd Principle of Lean Construction	Continuous Improvement/Built in Quality

Metrics 1 (Please TICK any column in front of the respective statement on the left)

24. Metrics about production are objectively recorded and analyzed	Never	Seldom	Sometimes	Often	Almost Always	N/A

25. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever	Sometimes	Most of the times

Metrics 2

26. Firms record their good or bad performances for the establishing of their standards	Never	Seldom	Sometimes	Often	Almost Always	N/A

27. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever	Sometimes	Most of the times

Response to defects 1

28. In the identification of defects, quality plans are prepared which clearly shows the responsibilities of the concerned members	Never	Seldom	Sometimes	Often	Almost Always	N/A

29. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever	Sometimes	Most of the times

Response to defects 2

30. The defects identified and remedial actions are recorded for future use	Never	Seldom	Sometimes	Often	Almost Always	N/A

31. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever	Sometimes	Most of the times

Response to defects 3 (Please TICK any column in front of the respective statement)

32. Quality is considered inbuilt and every team is quite confident, competent, educative and responsible enough to ensure quality in its product/activity at their own	Never	Seldom	Sometimes	Often	Almost Always	N/A

33. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever	Sometimes	Most of the times

Error Proofing 1

34. The precautions against defects are planned before the occurrence of any defect rather waiting for defects to occur	Never	Seldom	Sometimes	Often	Almost Always	N/A

35. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives	Hardly ever	Sometimes	Most of the times

of project in efficient/best manner			

Error Proofing 2

36. The supervisors/foremen always plan their work methodologies by duly consulting the team members on regular meetings i-e daily, weekly and, monthly meetings	Never	Seldom	Sometimes	Often	Almost Always	N/A

37. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever	Sometimes	Most of the times

Organization Learning 1

38. There is a mechanism involved in which a project based data is established in some form or the others for each and every project	Never	Seldom	Sometimes	Often	Almost Always	N/A

39. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives	Hardly ever	Sometimes	Most of the times

of project in efficient/best manner			

Organization Learning 2 (Please TICK any column in front of the respective statement)

40. Before undertaking any new project, all the available data is analyzed and necessary changes by the inferences driven are incorporated	Never	Seldom	Sometimes	Often	Almost Always	N/A
41. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

Organization Learning 3

42. All informations/knowledge techniques/changes are always and timely shared/presented to the concerned department in the organization	Never	Seldom	Sometimes	Often	Almost Always	N/A
43. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in	Hardly ever		Sometimes		Most of the times	

efficient/best manner			

3rd Principle of Lean Construction	**Customer Focus**

Flexible resources 1

44. The firm is in a flexible nature and can cope up the change by utilizing minimum amount of resources.	Never	Seldom	Sometimes	Often	Almost Always	N/A
45. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

Flexible resources 2

46. Firms do depend on the actual resources but change directions with the changing customer needs without losing much time or money	Never	Seldom	Sometimes	Often	Almost Always	N/A
47. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving	Hardly ever		Sometimes		Most of the times	

the objectives of project in efficient/best manner			

Flexible resources 3 (Please TICK any column in front of the respective statement)

48. All changes are passed immediately via telephone call first then through proper channel	Never	Seldom	Sometimes	Often	Almost Always	N/A
49. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

Optimize Value 1

50. The project value is defined with the customer and known to every one.	Never	Seldom	Sometimes	Often	Almost Always	N/A
51. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

Optimize Value 2

52. The customer needs are studied throughout a project rather only taken initially, understood correctly and the necessary production is executed by these needs	Never	Seldom	Sometimes	Often	Almost Always	N/A

53. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever	Sometimes	Most of the times

4th Principle of Lean Construction	Eliminate Waste

Supply Chain Management 1

54. Materials predominantly reach at the site just before their usage and minimum storage is kept.	Never	Seldom	Sometimes	Often	Almost Always	N/A

55. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever	Sometimes	Most of the times

Supply Chain Management 2 (Please TICK any column in front of the respective statement)

56. Materials stay at the nearest place where required at construction site rather storing at stores irrespective of location of use	Never	Seldom	Sometimes	Often	Almost Always	N/A
57. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

Supply Chain Management 3

58. Variability in market prices, productivity, availability, functionality in terms of materials, cost and resources are assessed according to the project and customers' demands	Never	Seldom	Sometimes	Often	Almost Always	N/A
59. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in	Hardly ever		Sometimes		Most of the times	

efficient/best manner			

Supply Chain Management 4

60. Firms select supplier who is reliable and can meet all the requirements in time. Changing supplier is never planned	Never	Seldom	Sometimes	Often	Almost Always	N/A
61. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

Optimize Production System 1

62. Completed work products/activities are made available to the next crew in a continuous stream or in small batches rather in large quantity/batches	Never	Seldom	Sometimes	Often	Almost Always	N/A
63. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

Optimize Production System 2 (Please TICK any column in front of the respective statement)

64. The number of employees in any activity can be utilized in their successor activity e-g mason team can be employed for scaffolding or steel fixing if free etc	Never	Seldom	Sometimes	Often	Almost Always	N/A
65. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

Optimize Production System 3

66. Planning and control department exists in the firm, with well defined authority	Never	Seldom	Sometimes	Often	Almost Always	N/A
67. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

Optimize Production System 4

68. Detailed sequencing, flow charts and scheduling is carried out and regularly consulted before and during the operations/activities	Never	Seldom	Sometimes	Often	Almost Always	N/A
69. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

Reduce Process Cycle Time 1

70. Projects are evaluated on the basis of constructability a part from cost and related specifications.	Never	Seldom	Sometimes	Often	Almost Always	N/A
71. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

Reduce Process Cycle Time 2 (Please TICK any column in front of the respective statement)

72. Coordination and cooperation among all the departments like mechanical, electrical, architectural, civil, design etc. is given enough importance	Never	Seldom	Sometimes	Often	Almost Always	N/A
73. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

Reduce Process Cycle Time 3

74. Risk management is carried out and planned	Never	Seldom	Sometimes	Often	Almost Always	N/A
75. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

Reduce Process Cycle Time 4

76. Master schedule plans, Back scheduling, look ahead plans duly taking into account the inputs of foremen and key workers are made. Progress is measured using some tools like percent complete etc	Never	Seldom	Sometimes	Often	Almost Always	N/A
77. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

Optimize Work Content 1

78. Standard, prefabricated, preassembled, repetitively construction elements are preferred.	Never	Seldom	Sometimes	Often	Almost Always	N/A
79. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

Optimize Work Content 2 (Please TICK any column in front of the respective statement)

80. Non value adding activities are properly identified like travelling, waiting, defective works etc. Efforts are made to either eliminate or minimum resources to be utilized on such activities	Never	Seldom	Sometimes	Often	Almost Always	N/A
81. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

5th Principle of Lean Construction	**Standardization**

Visual Management 1

82. The jobsite uses visual devices like posters boards news bulletins etc showing requirements of schedule, quality, safety, and productivity are shown to everyone	Never	Seldom	Sometimes	Often	Almost Always	N/A
83. Irrespective of whether you have implemented or not, do you	Hardly ever		Sometimes		Most of the times	

consider that statement on the left above is important in achieving the objectives of project in efficient/best manner			

Visual Management 2

84. The informative tools are understandable and regularly updated	Never	Seldom	Sometimes	Often	Almost Always	N/A

85. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever	Sometimes	Most of the times

Visual Management 3

86. Informations are pasted at respective sites and office area including public visiting places like eating places and canteen etc so that every worker should read it instead of pasting them to the office area only	Never	Seldom	Sometimes	Often	Almost Always	N/A

87. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in	Hardly ever	Sometimes	Most of the times

efficient/best manner			

Workplace Organization 1 (Please TICK any column in front of the respective statement below)

88. The firm gives due emphasize on Organizing and structuring the jobsite materials, tools and resources. Materials and tools are separately stalked as per their type and in sequence in which they have to be utilized close to the site	Never	Seldom	Sometimes	Often	Almost Always	N/A
89. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever		Sometimes		Most of the times	

Workplace Organization 2

90. The firm pay enough attention in keeping the offices and construction sites clean and in order	Never	Seldom	Sometimes	Often	Almost Always	N/A

91. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever	Sometimes	Most of the times

Defined Work Processes 1

92. Processes are Identified and continuously monitored	Never	Seldom	Sometimes	Often	Almost Always	N/A

93. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever	Sometimes	Most of the times

Defined Work Processes 2

94. The planned and regular meetings are carried out frequently on weekly, monthly etc basis instead of restricting the interaction to only site visits or inspections	Never	Seldom	Sometimes	Often	Almost Always	N/A

95. Irrespective of whether you have implemented or not, do you consider that statement on the left above is important in achieving the objectives of project in efficient/best manner	Hardly ever	Sometimes	Most of the times

Thanks for your cooperation