NTNU
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Last Planner System: Comparing Indian and Norwegian approaches

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Master of Science in Project Management
Submission date: June 2018
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Master Thesis

Project Management

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NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF CIVIL AND TRANSPORT ENGINEERING

Report Title: **Last Planner System: Comparing Indian and Norwegian approaches**	Date: 11/06/2018 Number of pages (incl. appendices): **181**			
	Master Thesis	**X**	Project Work	
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Abstract:

The Last planner system is currently being used in a variety of construction projects around the world with different approaches. In this paper, we compare the Indian and Norwegian industry because of their contrasting cultural settings, in order to gather experiences and formulate possible improvements to their LPS approaches.

A general literature study regarding LPS and its components was carried out. Data from three cases in India and six cases in Norway were collected with the help of three case specific and one generic interview in India and two case specific and one generic interview in Norway.

The study revealed similarities in scheduling and planning, root cause and constraint analysis, Project Percent Complete measurements (daily and weekly) during the meetings. The major difference was that the Indian companies use LPS in the middle of the project when they are subjected to problems and the Norwegian companies use it as a part of their system.

A major conclusion drawn in the paper is that the participants felt more ownership to the schedule and the activities like a promise of what they could do, rather than an order from the manager. Furthermore, the improvements in both the countries came when the participants they were allowed to be realistic and say "NO" to the weekly plan.

Keywords:

1. Last Planner system
2. PPC
3. Culture and People
4. Hofstede Analysis

Preface

This study has been conducted to satisfy the requirements of the NTNU subject, TBA4910 Project Management, Master Thesis. It builds upon the pilot study undertaken for the subject, TBA4530 Specialisation in Project Management and Construction Engineering, in autumn 2016. The study was supervised by Dr. Ola Lædre, Associate Professor at the Department of Civil and Transport Engineering and guided by Fredrik Svalestuen from Veidekke, Roar Fosse from Skanska and Mr.Kalyan Vaidyanathan from Nadhi Information Technologies.The topic was selected after a discussion between Ola and myself where I revealed to him about my interest in Lean construction and explained about my one year experience working in a construction project. Once the research questions were framed, it had to be narrowed down a bit more. I made a presentation to show my research questions and methodologies to Dr.Herman Glenn Ballard and received really good feedback from him, which sparked me to study more into the last planner system. Then, Ola and I had a discussion and narrowed down the research questions.

Based on the results from the study performed in this master thesis, a conference paper was written that has been accepted for publication. The paper was given the same title as the master thesis. Key findings with the Hofstede analysis and the interviews were the different cultural barriers that play a part in the usage of different components of the Last planner system in both the countries. I shall present this paper at the International Group for Lean Construction (IGLC) conference in Chennai, India in July 2018. The paper takes a theoretical look at the different components of the Last Planner system, the theory of Hofstede's six cultural dimensions which can then be used to compare against the practical findings that will stem from the experiences in India and Norway. If the results appear to be successful, then we could see the beginning of a new trend in the practices Last planner system as people will start to consider the cultral factors before implementing the Last planner system.

This document presents the master thesis and the appendices namely the literature search process, Interview guide and the conference paper that been ac-

cepted for publication. This study is original, independent work by me, with supervision and guidance from Dr.Ola Lædre, Mr.Fredrik Svalestuen, Mr.Roar Fosse and Mr.Kalyan Vaidyanathan.

Trondheim, 11 June, 2018

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Ramakrishnan Ravi

Acknowledgement

I would like to acknowledge those who have helped me with their contributions to this study. I would like to thank Dr. Herman Glenn Ballard for his valuable inputs for beginning this research and his advice about narrowing the research which led to studying in detail about the last planner system. I would like to think Mr.Srikanth Singh Chouhan, Mr.Pratap Vasipalli from Nadhi information Technologies, India, Mr. Roar Fosse from Skanska, Norway, Mr. Fredrik Svalestuen and Mr. Runar Alstad from Veidekke Entreprenør AS, Norway who took the time out of their busy schedules to allow me to interview them.

I would also like to thank Mr.Kalyan Vaidyanathan, my "Guru" and my inspiration for researching in this field, who has helped me right from the start till the end, both for this thesis and for the conference paper. I thank him also for helping me with providing three projects for the case study.

A sincere thank you goes to Dr.Ola Lædre for his support, guidance and his patience. Their input and feedback to this study has been invaluable and it is greatly appreciated.

This thesis is dedicated to my beloved Akka, Amma, Appa and the almighty god.

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Table 1: Abbreviations

LPS	Last Planner System
PPC	Percent Plan Complete
AEC	Architecture, Engineering and Construction
ILCE	Institute of Lean Construction Excellence
IGLC	International Group for Lean construction
WWP	Weekly Work Plan
NTNU	Norwegian University of Science and Technology
TFV	Transformation-Flow-Value
LPDS	Lean Project Delivery System
LBMS	Location Based Management System
FRS	First Run Studies
RNC	Reasons for non completion
PMC	Project Management Consultant
MEP	Mechanical-Electrical-Plumbing
BOQ	Bill of Quantities

Summary

The Last Planner system, a tool under Lean construction has been a new trend in construction and is adopted in various countries around the world. Last planner system when used in projects results in a better project performance be it optimization in cost, time and quality. However, people who have implemented this system have found it hard to make use of it's full potential. Based on this issue this Master Thesis, sets out to address three research questions:

1. How is the Last Planner system implemented in India and Norway?
2. What are the experiences gained from the implementation in India and Norway?
3. What are the potential improvements that could be made to the Last planner system considering the cultural aspects?

Addressing these questions will help to fill the identified gap related to implementation of the last planner system in India and Norway and suggest improvements that improve the practice of last planner system in both the countries.

Chapter 2, Methodology, details and describes the methods used throughout this study. A literature study, interviews with practitioners, and a set case studies of real projects implementing the last planner system in India and Norway were chosen to form the basis of the study.

Chapter 3, Literature Study, outlines the findings identified in the literature. It includes an introduction to Lean project delivery system, Lean construction and its principles, concepts under lean construction, components of the Last planner system, usage of the Last planner system with other lean tools, it's present status in India and Norway and theoretical background of Hofstede's six cultural dimensions.

The findings uncovered as part of the interviews and case studies are presented in Chapter 4. Findings and Discussion, are compared against the findings from the literature.

The Conclusion, Chapter 5, answers the two research questions by presenting the methods used in the construction site on how the last planner is implemented and presenting the various experiences gained with the last planner system in both the countries. Following this, the third research question is answered by presenting the recommendations for a better usage of LPS in both the countries, keeping the culture in mind.

To finish, Chapter 6 presents the future work that will stem from this master thesis and perform a future study.

Appendices presented in thesis are the Literature search process, Interview guide and the conference paper based on this study that has been accepted for publication.

Chapter 1

Introduction

This section explains the background and motivation of this thesis work.

1.1 Background

Construction projects are a complex system comprising of variety of processes that are diverse in nature, connected, interrelated and dependent on each other (Bertelsen 2003). Organizations that are temporarily involved in projects, for example just for a particular phase try so hard to establish their influence in construction project results (Bertelsen & Koskela 2005). Due to the involvement of too many stakeholders right from the beginning to the end of construction projects, when compared with other kinds of industries, the construction industry operates with a low efficiency that calls for improvement in the construction field (Allmon et al. 2000, Force & Britain 1998, Miller et al. 2009). Supporting this statement, Forbes & Ahmed (2010) claim that several industries that are running in parallel to the construction industry have shown significant improvement, while the construction industry has become less efficient and also the industry is very much in need of a better approach regarding planning the processes and decision making in those processes. Several researchers have not only said construction industry needs to improve, but have confirmed from their research that

the construction industry for quite a long time now is showing signs of improvement (Haas et al. 1999, Ingvaldsen & Edvardsen 2007, Thune-Holm & Johansen 2006, Kalsaas 2013).

As a result of this, management principles from other industries like production, have been brought into the construction industry in order to make the processes more efficient. First introduction was by Koskela (1992), where he applied the lean production principles to construction projects and wrote some research papers namely "Application of the new production philosophy to construction", and "An exploration towards a production theory and its application to construction". He also brought in the Transformation-Flow-Value (TFV)-theory of production into construction, which forms the basis of lean construction. This resulted in lean construction being a better approach than a traditional management approach, since it had a better theoretical background (Koskela et al. 2002).

Ballard and Howell have confirmed in their research papers, stating that construction projects tend to perform poor because of the factors like uncertainty or variability in workflow (Ballard & Howell 1998, 2003*b*). They have not only identified this problem with uncertainty in workflow that happens often in a traditional project management approach, but also have developed an antidote in the name of "Last Planner System (LPS)" in order to reduce those uncertainties in the workflow (Ballard 1994). During his early stages of research with LPS, Ballard was questioned about the importance of planning in construction projects, for which he answered that, the current standards for scheduling and budgeting construction projects results in a tremendous amount of waste, which needs to be managed (Ballard 1993). In order to align interests of various stakeholders involved in a construction project into a coherent network of commitments, Macomber et al. (2005) suggested that LPS as a process can help in generating an uninterrupted workflow and the planning process will be seen as a set of promises given by the workers to their higher management.

According to Mossman (2013, p. 1-5), LPS intends to improve the reliability and predictability of the plans used for construction activities during the implementation stage through an integrated approach. It has proven benefit on project performance for more than 20 years in multiple countries, across building construction, heavy civil

engineering construction, highway and infrastructure projects, including ship building and pit mining (Liu & Ballard 2008, Ballard 1993, Ballard & Howell 2003*b*, Alarcón et al. 2008). People these days are looking their projects towards a Lean construction persepective, which has resulted in the increased popularity and usage of lean management practices, such as Last Planner System (Priven & Sacks 2015). At present, construction industries are tired of using the traditional way of management and have started to move towards the lean management style. After implementing those principles, several organizations have seen significant changes in their project and the interests in implementing lean principles is increasing more in the construction sector (Thomassen et al. 2003, Alarcón et al. 2011).

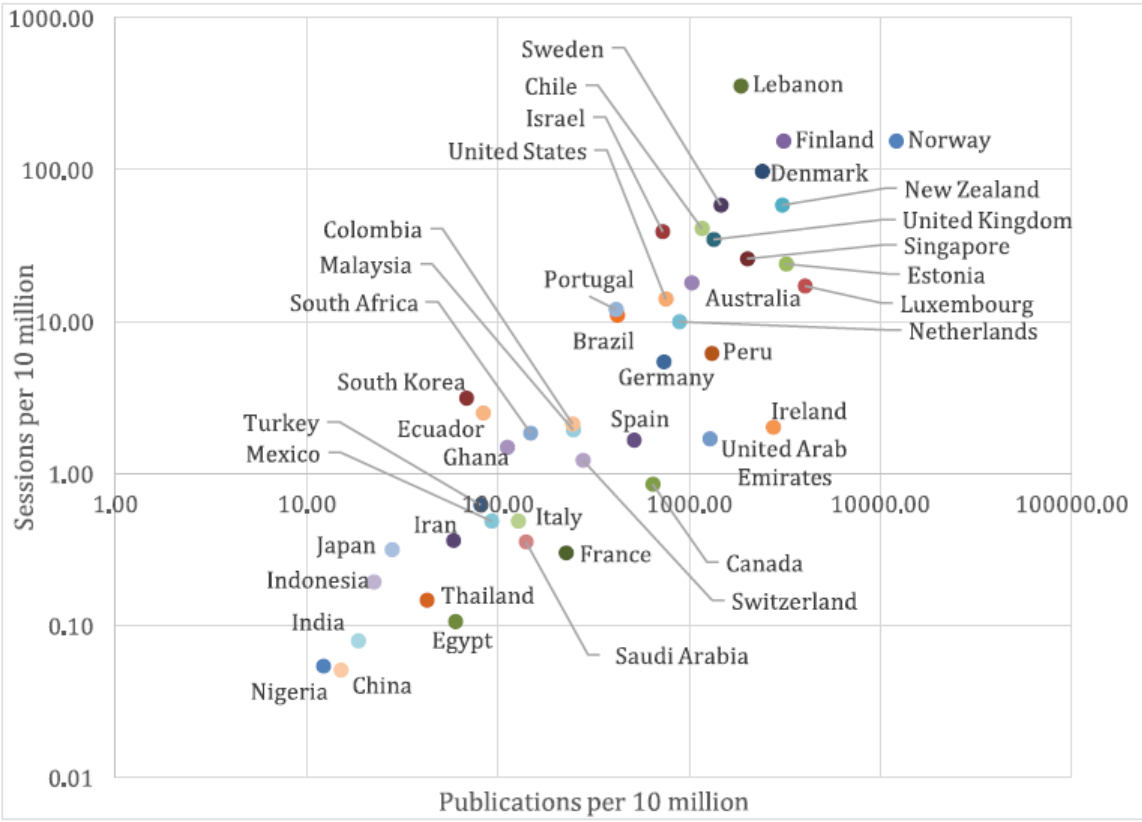

Figure 1.1: Log 10 representation of countries by publications and sessions per 10 million inhabitants(Engebø et al. 2017)

A study made by Engebø et al. (2017), as shown in Figure 1.1 found that – adjusted for the number of inhabitants – the interest for Lean Construction is much higher in Norway than in India. This correlates with previous work experience of the author in the Indian construction industry with various lean coaches and the present experience in the Norwegian construction industry with lean practitioners from different contractors namely Veidekke and Skanska. This has been a key motivation to compare the implementation of the last planner system between India and Norway, respectively. Given that Norway has been using the lean practices for a long time now than in India (Vaidyanathan, Mohanbabu, Sriram, Rahman & Arunkumar n.d., Kalsaas et al. 2009), this experience factor of the Norwegian lean practices have also been used in this thesis in order to suggest some practices to improve the lean practices in India.

1.2 Research Gap

The proposed contribution to knowledge is the clarification of what is a good approach to implement LPS, how to achieve better results with LPS, how can the different components of LPS be modified according to the project types and even the integrated usage of LPS with different other Lean tools. But the literature's have been generic in nature irrespective of the location of the project. The main aspect to look here is about the people who are actually using LPS and their local culture. It appears that the body of knowledge is missing a clear breakdown of what is a good approach to LPS considering a particular country, its various cultural elements and it's subcultures too. However, this cultural aspect can be viewed from two different aspects.

1. Should the LPS practices and the methods of introducing LPS in a project needs to be changed according to the people, or

2. Even with a good set of introductory tools for LPS into projects, people still find it hard. In those cases, do the people need to change their way of working for a better coordination and knowledge transfer?

It has been found from the pilot study of this thesis that, in India Last Planner system is being professionally facilitated by a company called Nadhi Information Technolo-

gies and a university named Indian Institute of Technology, Chennai. The methods in which these organizations help companies implement LPS have been figured out in the pilot study. A challenge for the lean coaches was that, it was hard for them to figure out a good set of training and introduction facilities that are needed for the people in a construction site. The interviews conducted for the pilot study revealed several reasons because of which it took a longer time to achieve positive results using LPS. The main reasons being expectation mismatches, participant's unwillingness to change etc. These findings regarding India would be a solid base when studying the LPS practices in the Norwegian side and comparing the results between the countries. This thesis addresses the cultural aspects of the two countries under comparison. By addressing this, the report aims to provide a reference point going forward, for both academics and practitioners, to get a better insight on the cultural aspects before implementing LPS in a project i.e. whether to change the way of practicing LPS or whether the change should be from the people, by gaining more insight about the culture of the local people.

1.3 Research questions

From the identified research gaps, the following research questions have been framed in order to fill the gap.

1. How is the Last Planner System implemented in India and Norway?
2. What are the experiences gained with this implementation in both the countries?
3. What are the potential improvements that could me made with respect to Last Planner System as a process considering the cultural aspects?

1.4 Limitations

A number of factors have been identified that limit this research. Firstly, a period of four months meant that limitations were placed on the amount of research that could

be undertaken. This included the number of journal articles that could be reviewed and the number of interviews and surveys that could be undertaken. Eleven major articles were selected for the study and a heavy bias was placed on results from India and Norway, as the study focuses on LPS in India and Norway. This is also one of the shortcomings of the research, as it focuses only on the Indian and Norwegian construction projects considering the fact that LPS has been implemented in all the major continents around the world.

An extensive study would have been needed in order to identify the methodological implementation of LPS in different project types. Due to the time restrictions of this report, such an extensive study could not be undertaken. Therefore, the results of implementation of LPS and experiences from LPS in the Indian context will be based on only three case studies. Even though there was an ease of access to study the Norwegian projects, a total of 6 cases from two contractors could only be studied. With these available case studies it was assumed that LPS practices were followed in the same way in all other projects performed by those contractors. Another limitation was taking in account of both sides of the arguments, as in this thesis only the perspective of the lean coaches were taken into consideration. The other side of the coin i.e. the construction workers and client's perspective were not studied.

Both Indian and Norwegian projects have measured their Percent Plan Complete (PPC) weekly, but the Norwegian contractors do not have a back up of the PPC measurements, whereas PPC measurements were obtained for the Indian projects. The study of culture in this thesis is done with the help of Hofstede analysis. A limitation with this analysis is that, it helps in identifying the problems, but this analysis does not provide solutions to those problems.

1.5 Structure of the Thesis

Chapter 2, Methodology, details and describes the methods used throughout this study. A literature study, interviews with practitioners, and a set case studies of real projects implementing the last planner system in India and Norway were chosen to form the

basis of the study.

Chapter 3, Literature Study, outlines the findings identified by the literature. It includes an introduction into Lean project delivery system, Lean construction and its principles, concepts under lean construction, Last planner system in detail, covers the components of the last planner system, it's usage with other lean tools and it's present status in India and Norway.

The findings uncovered as part of the interviews and case studies are presented in Chapter 4. Findings and Discussion, and are compared against the findings from the literature.

The Conclusion, Chapter 5, answers the two research questions by presenting the methods used in the construction site on how the last planner is implemented and presenting the various experiences gained with the last planner system in both the countries. Following this, the third research question is answered by presenting the recommendations for a better usage of LPS in both the countries, keeping the culture in mind.

To finish, Chapter 6 presents the future work that will stem from this master thesis and perform a future study.

Chapter 2

Research Methodology

The research questions will be answered by conducting a thorough literature study of publications mostly from India and Norway, case studies and interviews with various lean practitioners from India and Norway.

The results from the literature study will be compared and contrasted with findings obtained from interviews conducted with the construction industry practitioners from India. The results from the literature study will also form the basis of a case study review, for which data was obtained from a company in India.

2.1 Literature Study

One strength of a literature study is that it is a way to gain insight into the current body of knowledge on a chosen topic. A literature review focusing on the last planner system theories and its components was carried out in accordance with the procedures described by Boris et al. (2005). Keywords were used to search in research databases (IGLC Papers, Google Scholar and Scopus). Also, by using backwards snowballing (Banister & Van Wee 2015), it was possible to find more relevant literature from known sources. Literature's were studied with the objective to get a good understanding and breadth of knowledge on lean construction and the last planner system, it's

usage in India and Norway etc. A combination of both scholarly journal articles and industry publications is of interest. The review provided a foundation for the identification of various components of LPS components mentioned in the theory and the extent to which they are being used in real life projects in India and Norway.

In addition to the literature studies regarding LPS, an extensive literature review has been carried out regarding the cultural studies. This was because culture has a very big role to play in construction processes as stated by Johansen & Porter (2003). So, this study was based on what kind of barriers have people experienced in construction projects around the world and how well they have tackled those problems. Getting an insight to this helped with a better understanding of the cultural enablers/roadblocks that played a part during the implementation of LPS in India and Norway. In order to study more in detail about the cultures of India and Norway, the study of Hofstede analysis was selected. This analysis has been explained in detail under section 3.3.2.

Furthermore, due to the nature of literature publications, they can be used as a way to document the trends that have occurred over the years. To initiate the search, contact with professors from Norwegian University of Science and Technology (NTNU), Industry practitioners namely Dr. Herman Glenn Ballard, Mr. Roar Fosse, Mr. Fredrik Svalestuen and Mr.Kalyan Vidyanathan was sort as a point of departure for possible known sources related to this topic. NTNU's online databases were utilized for finding relevant journal articles, Google Scholar and International Group for Lean construction (IGLC) conference papers were used for finding the industry publications.

A critical evaluation was undertaken to ensure that each piece of literature included in this study was credible, reliable and relevant. A sample of this process is presented below.

It was decided to perform the initial search in NTNU library's Oria system for publications from India. But unfortunately, no articles were found relating to the usage of Last Planner System in India. So, the next database used was SCOPUS, which has peer reviewed articles and the quality is very much reliable.

The first search terms used were "Last Planner system AND "India". There were a total of 8 hits and 3 papers were relevant.

1. Vignesh, C. 2017, "A case study of implementing last planner system in Tiruchirappalli District of Tamil Nadu - India", International Journal of Civil Engineering and Technology, vol. 8, no. 4, pp. 1918-1927.

2. Raghavan, N., Kalidindi, S., Mahalingam, A., Varghese, K. Ayesha, A.2014, "Implementing lean concepts on Indian construction sites:Organisational aspects and lessons learned", 22nd Annual Conference of the International Group for Lean Construction: Understanding and ImprovingProject Based Production, IGLC 2014, pp. 1181

3. Vaidyanathan, K., Mohanbabu, S., Sriram, P., Rahman, S. Arunkumar, S.2016, "Application of lean principles to managing construction of an IT commercial facility - An Indian experience", IGLC 2016 - 24th Annual Conference of the International Group for Lean Construction, pp. 183

The next search was regarding LPS in Norway. The search terms used were “Last Planner system" AND "Norway". There were a total of 5 hits and 2 papers were relevant.

1. Skinnarland, S., 2012. Norwegian project managers and foremen’s experiences of collaborative planning. In Proceedings of the 20th annual conference of the International Group for Lean Construction (pp. 1-10).

2. Kalsaas, B.T., Skaar, J. and Thorstensen, R.T., 2009. Implementation of Last Planner in a medium-sized construction site. In Proceedings of the 17th Annual Conference of the International Group for Lean Construction, Taipei, Taiwan

3. Andersen, B., Belay, A.M. and Seim, E.A., 2012. Lean Construction Practices and its Effects: A Case Study at St Olav’s Integrated Hospital, Norway. Lean Construction Journal.

In addition, the reference lists in the selected articles were cross checked for other relevant publications. The above identified are the papers related to LPS in India and Norway. But focus was also on finding general articles and publications by Glenn Ballard and Greg Howell on the Last Planner system, as they both are very well known in the field of Lean Construction, especially LPS.

Hence the search words "Last planner system" AND "Ballard", "Last Planner System" AND "Howell" were used in Google scholar and 3 relevant articles were found out by screening them based on titles and abstract.

1. Ballard, H.G., 2000. The last planner system of production control(Doctoral dissertation, University of Birmingham).

2. Ballard, G. and Howell, G., 2003, July. An update on last planner. In Proc.11th Ann. Conf. of the Int'l. Group for Lean Construction (pp. 22-24).

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

One weakness is that while studying literature, one must take what they read at face value while trying to infer the real meaning and intention behind what is stated. This is counteracted by the fact that the academic literature reviewed in this study has all been written by experts in the field of Lean construction and more particularly the Last Planner system.

Almost half of the literature on LPS comes out of India and access to this has proven to be quite restricted, as the search process was undertaken mostly through NTNU, Norway. This has been confirmed by the fact that Google Scholar identifies a larger number of articles based on last planner system that can be found. Despite the limitations, it is assumed that the most relevant articles to this study have been found.

2.2 Case Studies

Case studies were chosen to validate the findings from the literature for the first two research questions i.e. the method of implementing LPS and the experiences gained through this implementation in India and Norway.

India

The case company "Nadhi Information Technologies", was chosen from India, since they are very well experienced in implementing the Last Planner system in construction projects. Nadhi Information Technologies, a consultant company facilitating contractors in India to implement LPS in their projects and having a lot of experience in implementing LPS in India, provided the cases. Nadhi Info. Tech which is the Chennai hub of the Institute for Lean Construction Excellence (ILCE). The CEO of the company Mr. Kalyan Vaidyanathan is one of the most respected authors in the field of Lean construction in India. This company is actively involved in the field of Lean construction since 2011, so they have quite a number of cases involving the usage of LPS in a project. However, for the thesis only three case could be studied regarding the implementation of LPS in Indian projects. This is due to the restricted access, because of which a lot of other projects could not be studied.

The author has an experience of working in Nadhi for a year and has been personally involved in one of their construction projects in India, where LPS was implemented integrated with the location based management system. So, the author has a good idea about how the last planner method is used in a project when implemented by the case company, Nadhi Technologies.

An email was sent to Mr. Kalyan Vaidhyanthan requesting for a case study project involving the last planner system. He was very happy to help his former employee (the author) and he replied back with email which had a brief explanation about three case projects. Out of the three cases from India, one was a Marine jetty project and two were residential projects.

Norway

In order to study cases in Norway, Mr. Ola Lædre helped with providing the author two contacts namely Mr. Roar Fosse and Mr. Fredrik Svalestuen who work with two major contractors in Norway respectively Skanska and Veidekke Entreprenør AS. Three cases were from Skanska and three were from Veidekke Entreprenør AS. So a

total of six projects ranging from residential, commercial and office building projects from those two contractors were studied. Since, contractors in Norway have a longer history of Lean practices, a project management system inbuilt with LPS and most importantly with a variety of projects and ease of access more number of projects could be studied from two of the major contractors in Norway.

Apart from case studies, an LPS implementation maturity matrix was created which is shown under section 4.1.4, in order to present the implementation grade of the LPS components for each of the projects studied. Hence, the lean experts who were involved in each project were asked to give the required score for each of the LPS components corresponding to their project. Due to the timing of the case studies in relation to the rest of the study, this matrix focused only on the first research question. The intention was to have the lean experts from both the countries identify the elements that they considered to be used in their LPS projects.

2.3 Interviews

The case studies were based on semi-structured open-ended interviews. The respondents were sorted in two categories, namely case specific respondents and generic respondents.

India

In order to find the interviewers, Mr. Kalyan Vaidyanathan, CEO of Nadhi Information technologies was contacted and the details of the Lean consultants in the case study projects were obtained. Contact was made with them and they were willing to do interviews. Interviews were conducted with three lean experts from the case study. The interviews were conducted through Skype to two Lean consultants, over two days in October 2017 and also an in person interview with one of them in January 2018 when the author travelled to India during that period. This in person interview was a generic interview as the participant was not involved in any cases.

Table 2.1: Interview participants-India

Name of the interviewee	Position and Organization
Mr. Srikanth Singh Chouhan	Lean Consultant, Nadhi Information Technologies, India
Mr. Pratap Vasipalli	Lean Consultant, Nadhi Information Technologies, India
Mr. Kalyan Vaidyanthan	CEO, Nadhi Information Technologies, India
Dr. N. Raghavan	Professor, Indian Institute of Technology, Chennai, India

The table below presents the participants interviewed in India, their position and organization.

Norway

Regarding the Norwegian side interviews, 2 interviews (one from Veidekke and one from Skanska) were conducted, where each participant was involved in 3 cases from a total of 6 cases in Norway. One was an in person interview and the other one was a skype interview as the participant was far way. Apart from this, another interview was conducted with a lean expert from Veidekke but this participant was a generic one.

The table below presents the participants interviewed in India, their position and organization.

Table 2.2: Interview participants-Norway

Name of the interviewee	Position and Organization
Mr. Roar Fosse	Lean Advisor, Skanska, Norway
Mr. Fredrik Svalestuen	PhD Candidate/ Design manager, Norwegian University of Science and Technology/ Veidekke Entreprenør AS, Norway
Mr. Runar Alstad	Lean Facilitator, Veidekke Entreprenør AS, Norway

So a total of 4 interviews were conducted in India and 3 interviews were conducted

in Norway out of which 3 interviews were case based and one was generic in the Indian side whereas 2 interviews were case based and one was a generic one in the Norwegian side. The interviews were solely conducted by the author himself and centered on the theme of implementation and experience with the Last planner system in their construction projects.

The interviews were structured around the interest in the following questions for the participants and in order to avoid bias, the respondents answered identical questions irrespective of whether they were involved in the case study or not.

- How was the Last planner system implemented in your project?
- Who were the actors involved in the Last Planner System meetings?
- What came the main issues discussed during the meetings?

The interviews proved valuable as they made a great starting point for developing the experiences gained by various lean coaches from both the countries. Experiences here refers to both positives and challenges faced by the lean consultants. Interviews also provided an insight into how practitioners view Last Planner system.

A key strength is that during an interview, it is possible to clarify questions, expand on answers and to delve much deeper into a particular topic of interest. One limitation of the interview process was that only a small number of practitioners could be interviewed. There were not many projects in India, involving the case company and LPS, as still the LPS in India is in its beginning stages. Only one side of the argument has been recorded as only the lean coaches were interviewed and not the contractors, subcontractors, foreman or clients. In total, seven interviews were conducted four in India and three in Norway. The biggest limitation of conducting interviews was distance. This meant that the option of in-person interviews was out of the question. This limited the amount of information that could be conveyed through the Skype in order to develop the case studies.

2.4 Document Studies

Apart from the three different research methods mentioned above, several documents were studied regarding the information about the case projects. The main motive of the document studies were to find the metrics that were recorded during the implementation of the Last Planner system. The metrics include Percent Plan Compelete (PPC), cycle time change in the activities and also the productivity measurements. The author conducted a document study of documents received from the respondents. The Indian documents were mainly project details (location, project cost, type of project etc.), changes caused in the project by implementing LPS, PPC measurements, productivity reports from site, cycle time charts etc. The Norwegian documents were mainly handbooks explaining their style of LPS implementation.

These documents were received through email and the reason for that being the distance. The main limitation with the document studies was that, some of documents, like contract between the client and the contractors could not be studied due to the protocols of sharing the information about the project through email.

With the help of the project data collected (changes in the LPS metrics) and the lean expert interviews (the extent to which different LPS components were implemented in the site and their experiences with LPS), cross analysis was done. These findings were analyzed with the help of Hofstede's six cultural dimensions to reveal the cultural enablers and roadblocks for implementation of LPS in both countries. The 2nd and the 3rd research question can be related to the Hofstede's cultural dimensions as how did culture play a part with the different kind of experiences that the lean experts experienced through implementing LPS in both countries and the future improvements that be made to LPS keeping the culture factor in mind. All three methods used in this study have their pros and cons and it has proved useful to include all forms when drawing the main conclusions.

Chapter 3

Literature Review

This chapter is meant for the reader to get an introduction to the theory relevant for understanding this study. It is divided into three parts. First part is about the origins of lean principles from the production industry and its application in the construction industry, comparison between a traditional style project management and a lean project management and the different tools used in lean construction. Moving to the second part, the focus is on LPS as this thesis is about the comparison of LPS practices between two countries. The theory behind various components of LPS have been explored and the usage of last planner system in the Indian and Norwegian construction industry have also been discovered from a variety of published papers in the conference of International Group for Lean Construction. The last part is about the knowledge sharing barriers in a construction project from which the most common barrier "National culture" has been identified and "Hofstede's cultural dimensions" was used to analyze the effect of national culture on the usage of LPS components.

This thesis is a continuation of the pilot study done by the author (Last Planner system: Indian approach) and hence one third of the literature review is a replication of what has been done for the pilot study (Ramakrishnan Ravi, 2017)

3.1 What is Lean?

3.1.1 The origins of lean production and it's application in construction

Lean production consists of quite the massive body of literature. This part-chapter introduces the origins of lean, describes the main principles of lean in production field and the transfer of this knowledge in the construction industry.

Taiichi Ohno (1912-1990), a Japanese engineer from Toyota developed the concept of "Lean" from a production process during his visit to a company in US where cars were produced in mass and he noticed quite a lot of wastes in the production process. He eliminated wastes in the production process looking it as a whole rather than looking at only certain parts of it. This process decentralized the decision making, which led to the replacement of the push system to the pull system, increasing the "Transparency" of the system which made sure that everyone involved in the production process knows what is exactly happening. Manufacturing and construction are totally contrasting industries, where manufacturing of products happens totally under a different setup, whereas construction of projects happen under highly uncertain environments with add-on pressures like scheduling, cost etc. and they are also unique and complex. The activity centred approach of mass production is being used in construction, the aim of which is to optimize the project activity by activity such that it creates value for the customer. The background of Lean construction is based on the production management principles of Toyota that is adapted into the construction industry (Howell 1999)

Ballard & Howell (1998) say that irrespective of manufacturing or a construction industry, only quality assignments should be made which enables the project teams to use the available capacity in a productive manner and also not fall behind the schedules.

According to Howell (1999), Ballard & Howell (1998), Picchi & Granja (2004), Lean construction based on the production principles mentioned above can be summarized in the following ways

- Eliminating Waste
- Improving the reliability of planning
- Creating a sequenced flow in the pull system
- Meeting customer's demands
- Involving the last person at every level of work and knowledge sharing between them
- Supplier and client involvement in the process
- Continuous improvement

Koskela (1992) was the first to provide a link between lean production and lean construction because of the fact that he criticizes the conceptual basis behind the traditional construction management. Koskela published his Doctoral thesis in the year 2000 (Koskela et al. 2000), where he refers that production theories uses either Transformation, flow or value framework, but he claimed that a production management system should be a mix of all the 3 framework which led to the formation of transformation-flow-value (TFV) theory of production. *TFV adds conceptions of production as consisting of flows of materials and information through networks of specialists, and the conception of production in terms of the generation of customer value.* (Ballard et al. 2001)

Lean construction can be interpreted in two different ways. First one, where ideas of Lean production can be used when implementing Lean construction. Second one, where lean production was used only as a theoretical inspiration to Lean construction. Here the second view is the most dominant view because it regards Kosekla's TFV framework as the starting point (Ballard et al. 2001, Koskela et al. 2002).
Hence the lean principles used in the manufacturing industry, founded by Ohno have been modified a bit and used as a theoretical base to form certain principles for the lean construction. In addition to this, Lean production's core idea of minimizing waste and maximizing value is accepted to a great extent in Lean construction and this led to a lot of studies on how to minimize waste in construction.

3.1.2 What is lean thinking?

"Muda" is a Japanese word, which means waste. Considering these wastes that is of no use, there should be a remedy for minimizing this and it is the "lean thinking". Lean thinking in general has a long history of generating radical improvements in fields like manufacturing, health care and construction (Poppendieck & Poppendieck 2003).

"Lean thinking is lean because it provides a way to do more and more with less and less i.e. less human effort, less equipment, less time, and less space—while coming closer and closer to providing customers with exactly what they want" (Womack & Jones 1997)

Womack & Jones (1997) in their research have listed the basic principles of lean thinking:

- **Specify Value:** Value is the starting point for lean thinking. The customer precisely defines value in terms of specific products i.e. goods or services with specific capabilities and value is actually created by the producer. This step is critical because if the value is defined based on technologies and assets and not defined based on the product itself, then it is pretty much certain that the definition of value is almost certain to be skewed. This leads to the production of wrong goods which then ends up as "Muda" (Womack & Jones 1997).
- **Identify the Value Stream:** The three critical management tasks required to create a specific product are
  - The problem-solving task - detailed design and engineering to production launch,
  - The information management task - detailed scheduling to delivery
  - The physical transformation task - Yielding of raw materials to a finished product in the hands of the customer.

  The three processes combined together is called the "Value Stream". This step is done to identify the entire value stream for each product or a product family,

which in turn exposes enormous amounts of "Muda". Specifying the value stream paves way to three types of actions occurring along the value stream which are, finding steps to apparently create the value, finding steps that create no value but still cannot be avoided due to current assets and technologies and the final one that is finding steps that create no value but which can be avoided (Womack & Jones 1997).

- **Flow:** The next step in lean thinking is to create a smooth flow for the processes identified in the value stream that create value. The basic formula for creating a good flow is to focus more on the product, its needs and all the activities involved in designing and providing the product. Flow thinking has a basic problem, which is its counter intuitiveness. Creating a flow is done by redefining the work of functions, departments and firms in such a way that they can understand the needs of the employers and that they involve themselves totally in the project which then finally becomes their personal interest to make the value flow (Womack & Jones 1997).

- **Pull:** The basic principle of the pull ideology is to produce the products based on what the customer is exactly demanding, rather than making the line flow all the time and pushing the production process in order to have the products available all the time. If implemented properly, the pull process results in a dramatic reduction of waste, which usually comes in the form of over-production (Womack & Jones 1997).

- **Perfection:** In the last step, which is Perfection, one main phenomenon controls the whole process and it is called "Transparency". The best thing about a lean system is that, everyone (subcontractors, first-tier suppliers, system integrators, distributors, customers, employees) who are involved in the process right from the start to end, can see everything that is happening during the project, which leads in discovering better ways to create value. Instant feedback can be given to the employees in order to help them developing as a better worker.The aim is to involve every member in an organization to make small changes for gradual improvement seeking long-term improvement (Womack & Jones 1997).

Lean thinking paves a way to specify the value, sequencing the activities that create more value in the best, perform the activities effectively without any sorts of interruption. Lean thinking also contributes to betterment of the workers and the work done by providing an immediate feedback on their attempts for converting waste (for ex. less productivity) into value. In the present situation where jobs are being destroyed in the name of efficiency, lean thinking provides a completely different way to create things.

On getting a good insight into the lean principles and lean thinking, the next section places a focus on the comparison between traditional ways of management and the lean management style.

3.1.3 Comparison of the traditional approach principles and the principles of Lean Construction

"Where current practice attacks point speed, lean construction attacks variation system wide." (Howell 1999). The traditional practice of project management in construction is inadequate because it does not rest on the basis a TFV (Transformation view, Flow view, Value generation view) framework (Johnston & Brennan 1996, Howell & Koskela 2000), but rather it rests only on the Transformation view. According to Koskela (1992), Koskela et al. (2000, 2002), several disadvantages from a traditional management practice are as follows:

- Flow is neglected: Since, the traditional way of project management is controlled through output measures and different activities in the project are managed using a centrally applied scheduling, it does not succeed in creating value and reducing workflow. If projects are controlled by tracking the completed activities and the cost spent for those activities, it fails in assuring a reliable work flow.

- Lack of coordination between the groups: Certain supervisors who are in charge of some activities in the site, trying to improve the performance of those activities, actually end up in reducing the total project performance. The deeper problem here is, attempting to optimize each and every activity leads to less

standard outcomes for the project. When projects are complex and uncertain, scheduling and budgeting during the early stages is actually inaccurate.

- Segmented control. Control of the project is done by keeping cost control over single tasks and units, which further increases the utilization rates and also large number of crews. As a result of this, more space and attention should be given for the materials and also correction of errors will be slow during the execution of the project.

So, a new approach is required which has the basis of the Transformation-Flow-Value approach. A lean project delivery system is well structured, controlled, and improved in such a way that it satisfies all three goals of the TFV framework, i.e., the transformation/flow/value goals proposed by Koskela et al. (2000). Koskela et al. (2002) argues that Lean construction has a better theoretical framework that makes it more effective than the traditional construction. As mentioned before, the main difference between traditional project management in construction and lean construction is that, the traditional approach only focuses on the transformation of inputs to outputs, whereas Lean construction acknowledges all the goals of the TFV framework. The table below shows both the theoretical and practical differences between a traditional and lean management.

Table 3.1: Lean vs Traditional (Koskela et al. 2002)

Lean	Traditional
Focus is on the production system	Focus is on transactions and contracts
TFV goal	T goal
Downstream players are involved in upstream decisions	Decisions are made sequentially by specialists and "thrown over the wall"
Product and process are designed together	Product design is completed, the process design begins
All product life cycle stages are considered in design	Not all product life cycle stages are considered in design
Activities are performed at the last responsible moment	Activities are performed as soon as possible
Systematic efforts are made to reduce supply chain lead times	Separate organizations link together through the market, and take what the market offers
Learning is incorporated into projects, firm and supply chain management	Learning occurs sporadically
Stakeholder interests are aligned	Stakeholder interests are not aligned
Buffers are sized and located to perform their function of absorbing system Variability	Participants build up large inventories to protect their own interests

From the comparison between the traditional and lean management, traditional projects does not consider the aspect of flow, as it creates variability in the workflow and it lacks in creating opportunities for better coordination between project teams. Hence bringing in Lean thinking to a project can be a very good addition to the projects as it considers the interests of stakeholders, works with the TFV goal, promotes continuous learning, creates a better coordination between workers which sets up a better environment for the planning process.

Now with a set of Lean thinking principles and usage of these principles in projects, the next section gives a detailed framework of how exactly these elements can be incorporated into projects in a sequential and a systematic manner, hence resulting in a "Lean project delivery system"

3.1.4 Lean Project Delivery System (LPDS)

When projects are structured in such a way that it delivers the final product by minimizing waste and maximizing the value, they are called as "Lean Projects". Not only have the goals differed between Lean project management and traditional project, also the structuring of the different phases and relationship between the participants and phases during different stages of the project is also different. (Koskela et al. 2002)

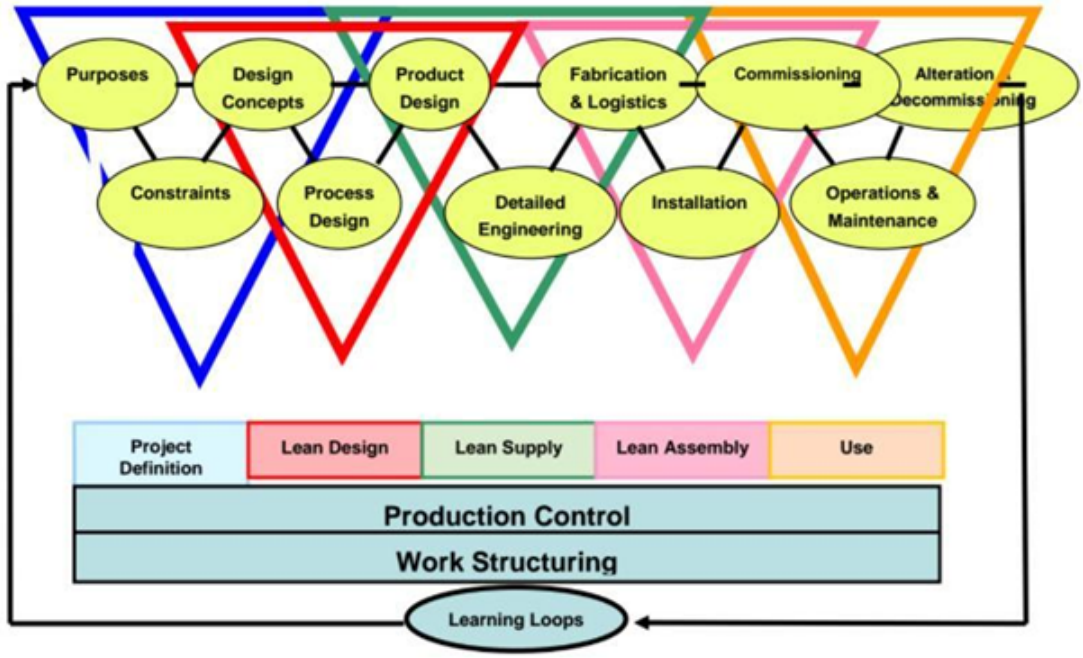

Figure 3.1: Lean Project delivery system (Ballard & Howell 2003*a*)

The figure above is about the different stages in a LPDS and each phase is explained in detail below from the guidelines given by Koskela et al. (2002), Ballard & Howell (2003*a*), Ballard (2008):

1. Project definition: The first phase is the project definition, which comprises of customer and stakeholder purposes, design concepts and design criteria. It is necessary for the stakeholders (people involved in the project from the initial

stages to the end of the project including the production team) to have a conversation between them regarding the elements mentioned above, as they are dependent on each other (Koskela et al. 2002, Ballard & Howell 2003*a*, Ballard 2008) .

2. Lean design: The next phase is the Lean design phase where the product and process design are aligned in accordance with the Project definition. When there is a search made for values and if it reveals opportunities that are in line with the constraints of the customer and the stakeholder, then this phase is reverted to the project definition phase. Here in this phase decision-making is delayed till the last moment, giving more time in order to explore the different alternatives, which is in contrast to the traditional style where decisions are taken as soon as possible which causes rework and sometimes, conflicts between different design specialists (Koskela et al. 2002, Ballard & Howell 2003*a*, Ballard 2008).

3. Lean supply: Then comes the Lean supply where detailed engineering, fabrication, and delivery of products are done. To do these activities some prerequisite design factors should be known which would then become easy to do the fabrication as per the requirements and delivery as per the time. The supply of 'engineered-to-order' products plays a key role in determining the pace of the project delivery and this phase of Lean Supply includes initiatives which can be used in reducing the lead time (Koskela et al. 2002, Ballard & Howell 2003*a*, Ballard 2008).

4. Lean assembly: The last phase is the Lean assembly, where the materials are delivered to the customer and information regarding their installation are provided. Once the customer has the beneficial use of the facility, that is the point when the phase is completed i.e. typically after commissioning and start-up(Koskela et al. 2002, Ballard & Howell 2003*a*, Ballard 2008).

With the help of this Lean project delivery system, lean elements can be incorporated right from the start to end of the project enabling the project to be defined better during its early stages, enabling the product and process design simultaneously during

the design stage, enabling to get exact information about the materials to be ordered from a proper design hence resulting in a better supply chain and finally executing and finishing the project with respect to the demands of the customer.

Once it is clear about how the Lean process can be incorporated in projects, it is now time to move on to the different tools under this Lean umbrella that can be used for achieving better results in projects.

3.1.5 Lean Construction tools

There are various tools that are used under the umbrella of "Lean". According to Ansah et al. (2016), the lean construction tools that are used at present are:

1. Last Planner System (LPS)
2. Concurrent Engineering
3. Daily Huddle Meetings
4. 5S
5. First Run Studies
6. Visual Management
7. Fail Safe for Quality
8. Construction Process Analysis
9. Kanban (Pull System)
10. Just-In-Time
11. Work Standardization
12. Value Stream Mapping
13. Statistical Process Control (SPC)
14. Work Structuring

15. Pareto Analysis
16. Poka-Yoke (Error Proofing)
17. Continuous Flow
18. Six Sigma
19. Failure Mode and Effects Analysis (FMEA)
20. Bottleneck Analysis
21. Kaizen
22. PDCA (Plan, Do, Check, Act)
23. 5 Whys
24. Muda Walk
25. Root Cause Analysis
26. Check Sheet
27. Synchronize/Line Balancing
28. Jidoka/Autonomation
29. FIFO line (First In, First Out)
30. Team Preparation

However, this thesis is concerned more with the practice of the Last Planner System. So in the next part of the literature, the Last Planner system as a process, it's history and development, it's components, various metrics used to measure the performance of the Last planner system etc. have been explained.

3.2 Last Planner System

The Last Planner System was developed by Glenn Ballard and Greg Howell and it is a system for production planning and control assisting in smoothing variations in construction workflow, developing planning foresight, and reducing uncertainty in construction operations. Construction projects, after the introduction of last planner system has a reliable plan, predictable workflow and an improved production performance (Alarcón 1997, Tommelein & Ballard 1997, Ballard & Howell 2003*b*, Ballard, Kim, Jang & Liu 2007, González et al. 2008).

Ballard & Howell (2003*b*) concluded that LPS focusses more on the planning and production control rather a cybernetic followed in the traditional project management approach. Here, traditional project management is referred to as a cybernetic model because of the elements such as a standard of performance, measuring the performance during the output etc (Koskela & Howell 2002, Hofstede 1978).

Though LPS was developed initially to tackle workflow issues and improve plan reliablity, in the later stages a lot of developments have been made to the system, which resulted in several other principles. The five key principles of practicing LPS according to Hamzeh, Ballard & Tommelein (2012), Mossman (2013), Ballard (2000*b*), Ballard, Hamzeh & Tommelein (2007), Ballard et al. (2009) are:

1. To plan the tasks in detail closer to their execution dates,

2. To plan tasks with people who are actually going to execute them,

3. To identify and remove constraints before the execution of a particular activity,

4. To make secure and reliable promises and

5. To learn from failures and to prevent them from occurring in the future. Its implementation supports the development of collaborative relationships among project stakeholders.

3.2.1 Brief History and Development of the Last Planner System

This section describes why LPS was introduced into the construction sector and how it developed as a process over the years.

History and Development of the LPS

The figure below, is a time-line which shows the origins of the Last planner system and how it developed as a process over the years.

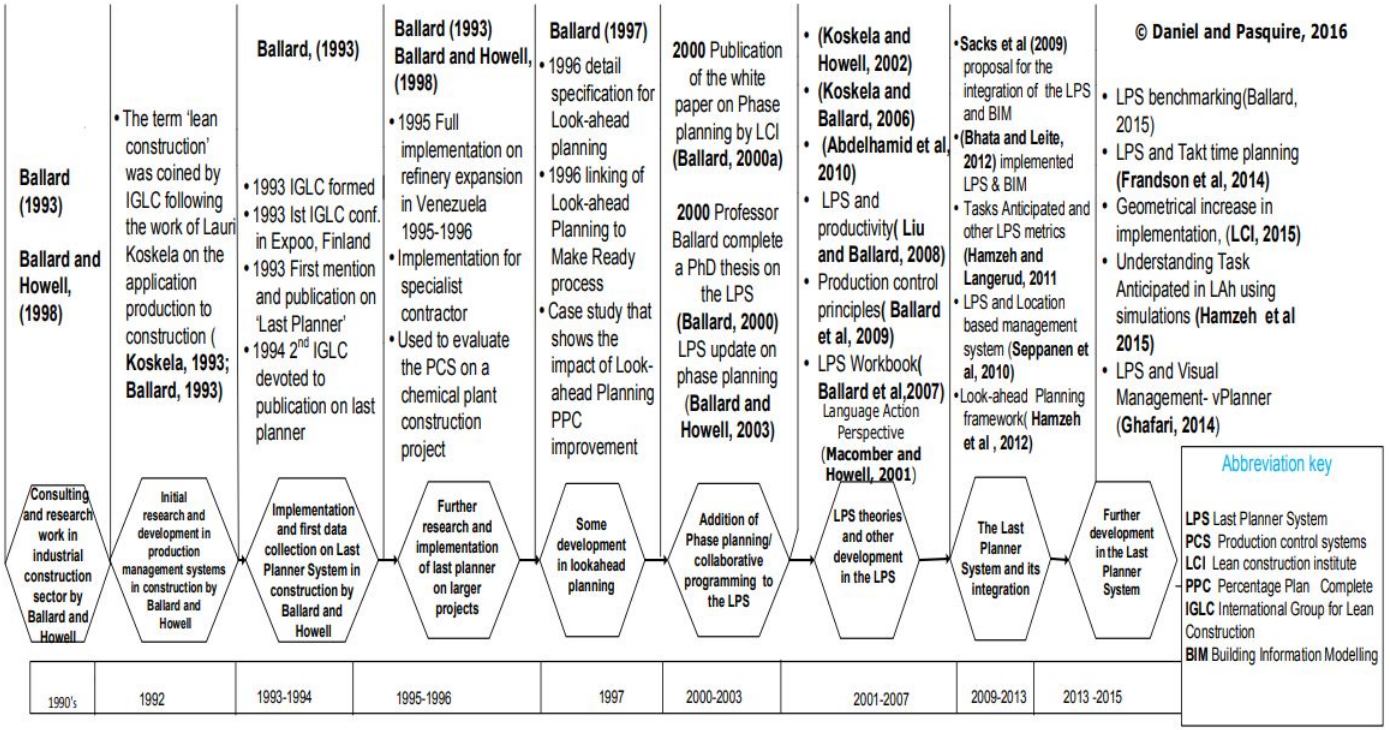

Figure 3.2: History and development of LPS Daniel et al. (2015)

Some inferences that can be made from the figure on the history and development of the Last Planner System are:

- Ballard and Howell worked in the Industrial sector during the early 90's, and developed the last planner system as they were unhappy with the working system they were dealing with (Daniel et al. 2015, Ballard & Howell 1998, Daniel et al. 2015). Initially LPS was used to improve workflow and improve the planning reliability (Ballard 1993, Ballard & Howell 1998, Ballard 2000*b*) and over the years various other principles have been added with the help of research and development in the field of Lean construction (Ballard 2000*b*, 1993, Daniel et al. 2015).

- Lauri Koskela's seminar work abour the usage of production principles in construction in the year 1992 led to the formation of the term "Lean construction" and the International Group for Lean Construction. The inaugural conference for this group took place in Espoo, Finland and a paper about the Last Planner was published in that conference (Ballard 1993, Daniel et al. 2015).

- During 1993/94 attempts were to implement LPS in construction projects, but they were not full fledged. In a refinery project in Venezuela during the year 1995/96 was the first full fledged implementation of LPS (Ballard 2000*b*, 1993, Daniel et al. 2015).

- Glenn Ballard's PhD thesis on Last planner system (Ballard 2000*b*) is said to be the most cited work (1119 citations) in the field of Lean construction and various master students, PhD students and even industry practitioners have been using it as a primary reference to learn about LPS.

- Daniel et al. (2015) in his research has found that the Last planner system has been implemented in 16 countries, all the major continents and has been integrated with various other systems such as Building Information Modelling (BIM), Location Based Management System (LBMS), Takt Time planning etc. Glenn Ballard has also created a benchmark for LPS which gives an insight into the different components of LPS (Ballard & Tommelein 2016).

Looking at the history and development of LPS, Glenn Ballard and Greg Howell have been the main forces behind the foundations and development of LPS. Research papers have confirmed that during the early stages of development of LPS there have been projects where certain LPS components like phase planning were not implemented in a full fledged manner, but certain research papers have also found that publications of various research papers by Ballard and Howell have played a major part in the betterment of implementation of these components.

Before having a detailed look at the various components of a Last planner system, the two main processes that are used in LPS for effective implementation of all the components are explained below. These processes are called shielding work from uncertainties and Pull planning process.

3.2.2 Shielding work in Last Planner system

During his first publication in the year 1993, Ballard clearly expressed his thoughts against the conversion process model that was based on a sequential thinking in order to manage construction projects. With norm of so-called "Fast track projects" in construction these days, conversion process model seemed to be outdated especially in projects where engineering, procurement, and construction overlap in time. Ballard wanted to replace this conversion process model through the Lean construction techniques thus improving the production planning and control of construction projects (Ballard 1993).

Ballard (1993) called the process as Last planner system and the people working to execute the assignments as last planners because he argued that the last mile person in the chain played a key role in producing good assignments, but bad logistics and delivery of resources prevented him from creating quality assignments even when he spent a huge amount of his time hustling resources and fighting fires. It is the responsibility of everyone above the last person in the chain to give them quality assignments to work on and shield the Last Planner “from an erratic flow of resources. Here shielding means knowing the difference between what “should” be done, from what “can” be done, and what “will” be done. In this SHOULD-WILL-CAN process,

the last planner has to essentially know what he "should" do within the limits of what he "can" do (Aslesen & Tommelein 2016).

So, the assignments are tested for quality requirements based on its definition, soundness, sequence, size and learning. The assignments which pass these questions are termed as quality assignments and are given to the site labour team to execute them. The quality of assignments given through shielding essentially determines the the Last Planner's ability to produce good assignments. By making quality assignments, Shielding is accomplished, thereby increasing the reliability of the Plans (for ex. Lookahead plans, Weekly work plans etc.) (Ballard & Howell 1998, 2003*a*, Ballard 1997, 2000*b*).

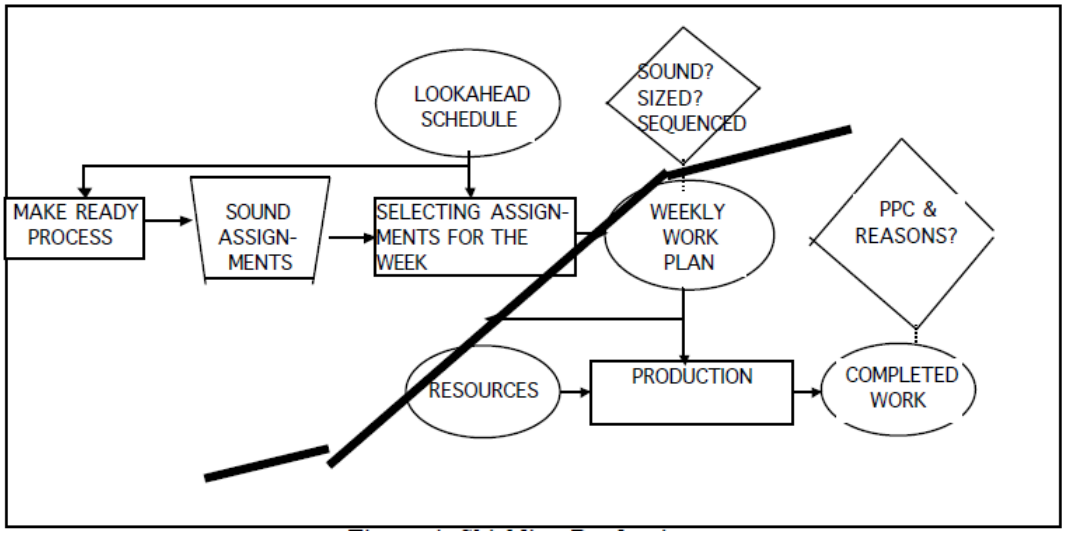

Figure 3.3: Shielding the production units (Ballard & Howell 1998)

Hence the purpose of shielding is to to provide quality assignments to work on, to the site team who execute the assignments. If this fails, delays can be caused in the form of bad sequencing off activities, reworks, waiting for the workfront etc. which at the end results in delay of the whole assignment. In order for the other LPS components to be effective, shielding workers is a mandatory thing to focus on.

3.2.3 Pull Planning in the Last Planner system

Traditional construction projects is based on push mechanisms, where inputs are pushed into the processes, based on the target deliver/completion dates. In a push driven approach, the resources that are required to perform an activity in the site will be available during the early start time of that activity. Hence, the activities passively wait for its resources (instructions, labor, materials, equipment, and space) to arrive. But, here the problem is when a resource is not available, it not only affects the activity that is to be done, but also the queuing activities. It is possible to start the work with an incomplete set of resources, but it can result in a negative productivity (Howell et al. 1993, Thomas et al. 1989, Tommelein 1998). The Last Planner system uses the pull mechanisms where materials/resources are pulled into the process, only if the processes are capable of doing that work. Hence, Last Planner is a type of pull system (Ballard 2000*b*).

Pulling is a method of introducing materials or information into a production process. (Ballard 2000*b*)

Pull planning is based on the approach of finishing the products in an optimal manner, but not compromising in terms of quality, cost and time in order to satisfy the customer demand. The key to success pull planning is to manage the operating expenses and the in process inventories. In order to implement the pull process, it is important to select the resources not only based on the the activities that are preceding, but also the work-in-progress activities and the resources downstream (successor queues and activities) in the process (Tommelein 1998). The resources and information are released based on the amount of work in process, the quality of available assignments, the due dates etc. in a pull driven approach (Hopp & Spearman 1996). But, Ballard (2000*b*) says in construction projects, the resources are pulled mainly based on the target completion dates and it applies differently for different types of internal customers .

Howell and Ballard describe pulling as a process that is based on working backwards from a target completion date and is done by sequencing the tasks in such a way that its completion releases the work.*"A rule of pulling is to only do work that releases work - requested by someone else"* (Ballard & Howell 2003*b*).

During pull planning, the team members from various departments, write two main things on a sheet of paper and these are taped on a wall

- What are the works they should perform in order to release the work to another department
- What are the works that should be released to them by other departments

Pull Planning can be used for sequencing the activities, irrespective of the time horizon. The identification and definition of the milestone is an important aspect of Pull planning and it is critical to identify the conditions that satisfies the milestone activities. After the conditions are accepted, then comes the pulling part where the teams start working backwards from the milestone and when one milestone is completed it sets the stage for the beginning of another one. One advantage of pull planning is that, it enables a team to respond flexibly, when projects are subjected to differences about how the future will turn out and what actually happens. (Ballard & Tommelein 2016).

From the latest research Ballard & Tommelein (2016) has expressed his concern during the pull process that the specialty contractors do not have sufficient understanding of the work and do not contribute enough to the planning because they are employed late in the project. Teams involved in the process of pulling are keener in completing their own tasks should, but they should exactly know about the work they would be performing and the ways in which the work can be done. This in turn develops the best plan for all the parties that are involved in the pull process. Lean Construction Institute (LCI) recommends using pull techniques and team planning to develop schedules for each phase of work, from design through turnover. When phase schedules are created using the pull system the result is based on the targets and milestones from the master schedule, which forms a basis for the lookahead plan (Ballard, Hamzeh & Tommelein 2007).

Hence, pull planning is an integral part of LPS, that can be used to plan at any level, be it a master plan or a phase plan, but the important thing is to identify the milestone and define it properly so that the project team has an ease in pulling the activities in that particular plan. Pull planning meetings should involve all forms of stakeholder, right from the decision making authorities till the execution engineer in site. With

uncertainties around the project, there might be situations where plans might need to be changed, but the advantage here is pull planning gives the extra room for flexibility when the plan needs to be changed.

In the next part, the various components of LPS, their benefits and to what extent they can be used to reduce variability and increase reliability in plans are explained below.

3.2.4 Components that constitute a Last Planner system

An extensive study from Daniel et al. (2015) (figure 3.4) shows the different components of LPS used in 57 case studies across 16 different nations (including seven from Norway and one from India). This study comprises of the all the previous IGLC papers that have been published for the past 23 years. Figure 3.4 gives an overview of the components that are frequently used in the all the cases that were studied. This case study from the literature has been used to identify the LPS components that are used around the world and it has proven to be a good foundation to compare the components mentioned in the literature with the actual components that are used in the Indian and Norwegian projects. In the same study Daniel et al. (2015) has expressed his concern about the limited usage of certain LPS components, as this insufficient degree of usage prevents using the full potential offered by LPS (Lagos et al. 2016). It was identified from a research carried out by the Production Management Centre of the Catholic University of Chile (GEPUC) that better usage of Lookahead planning, constraint analysis and removal was directly correlated with the PPC measurements and it was identified that there was a significant improvement in the PPC measurements (Alarcón et al. 2008).

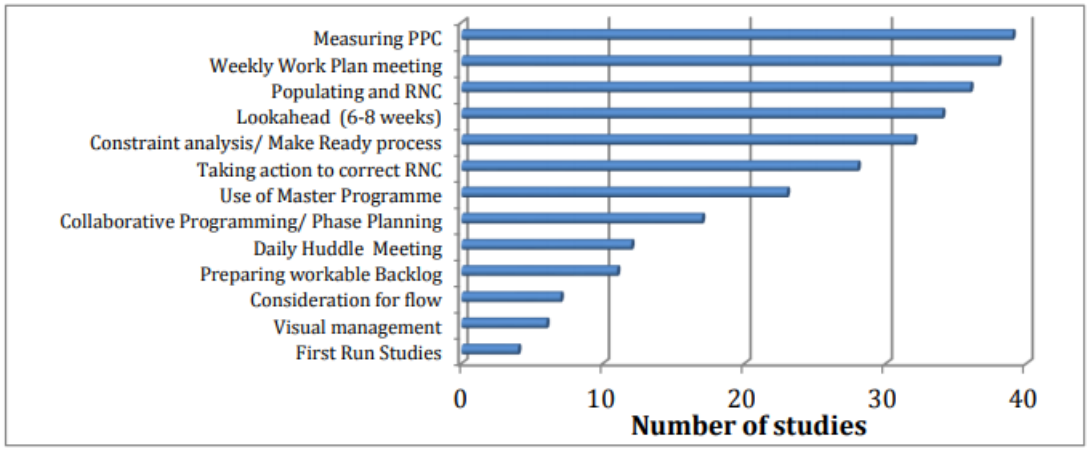

Figure 3.4: LPS components according to Daniel et al. (2015)

Trend of LPS components

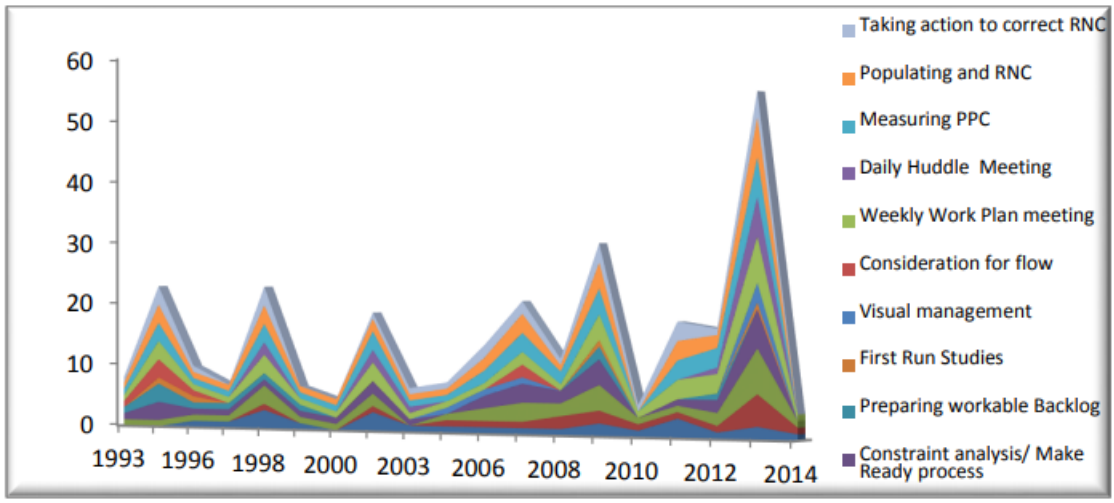

Figure 3.5: Trend of LPS components according to Daniel et al. (2015)

Figure 3.5 shows the development of each and every component of LPS right from its beginning stages till the present time. From this trend graph, inferences that can be made are even though there is inconsistency in usage of several components, the

graph remains positive for most of the elements indicating that the components have been in a positive trend and it will be used to a better extent. There are few exceptions such as workable backlog and First run studies (FRS), as they are reported to be not implemented to a full extent.

In the upcoming subsections below each and every component under Last planner system has been explained in a detailed manner.

Master Scheduling

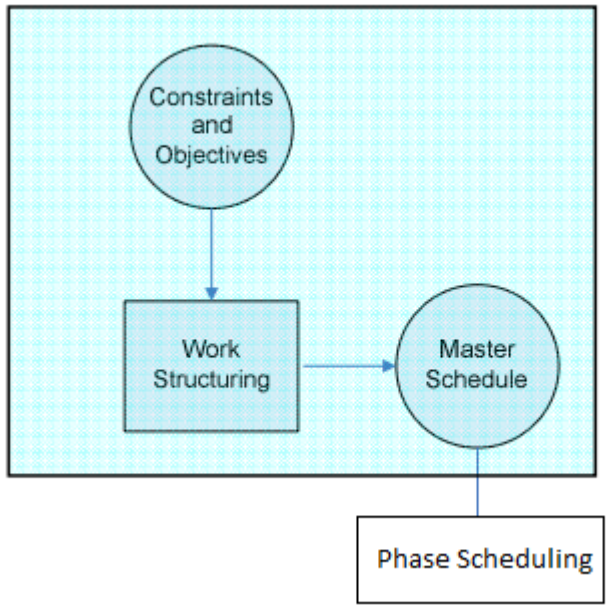

Figure 3.6: Master Schedule in LPS (Ballard, Hamzeh & Tommelein 2007)

The master Schedule a.k.a the general project schedule is made ready before the start of any work. It represents the project level activities that will be carried out during the entire life of a project in relation with the contract documents. This schedule is categorized based on the function, area, or product (Ballard, Hamzeh & Tommelein 2007, Ballard 2000*b*). Front end planning is done based on the Bill of Quantites of

the Project's location breakdown structure which forms as a strong base for creating the master plan (Seppanen et al. 2005). Overall project duration and key milestone dates are determined using Critcial path method (Tommelein & Ballard 1997) and represented visually in the form of Gantt chart, PERT (Program Evaluation Review Technique), line of balance etc (Hamzeh et al. 2008). The master schedule can be subjected to changes by modifying construction methods, rescheduling major tasks etc. (Bhatla & Leite 2012).

Master plans are partly approximate because they are used for overall monitoring and controlling of project progress, as more detailed plans are required for practical implementations in the site. Site managers also tend to use it for planning the individual project tasks. When looking at a master schedule one can get a good insight about the flow of activities and it does not include activities with short duration (Kankainen & Sandvik 1996). Since it is an approximate plan, certain errors in estimating cost and quantities of work should be taken into consideration while preparing more detailed plans. Based on the master plan, the milestones of subcontractors should be determined by general contractors (Junnonen et al. 2004). This master schedule is very critical to LPS as it is starting point to all the planning processes that are to follow. Establishing a clear view on the master schedule, helps to give an overview of the whole project. Master schedules have the lowest level of detailing and this aspect is used for identifying different phases of a project, which sets up nicely when starting to plan for a phase.

Phase Scheduling

Ballard presented a white paper on the topic of Phase scheduling recommending the use of pull planning techniques thereby developing a schedule for that particular phase of the project by the participation of all the trades who are to do the work in that phase. Phase planning became more dominant after the year 2000 because of this White paper on phase planning. A phase in a project project is identified from a master schedule which has a start and end date with a brief description about that phase. (Ballard 2000*a*). Pull planning is done by working backwards from a target completion date, such that each task is defined properly and completion of a task by

a group releases work to the next group (Ballard & Howell 2003*b*, Howell & Ballard 1999, Seppänen et al. 2010, Hamzeh et al. 2008). For example different phases in a project can be foundation phase, structural phase, finishing works phase etc.

Phase scheduling is the link between work structuring and production control such that the participants after identifying the phase and activities in that phase, work collaboratively towards the completion of a particular milestone in that phase (Ballard & Howell 2003*b*, Tsao et al. 2014). An important success factor in phase scheduling is the involvement of subcontractors as better transparency to them contributes to a better work flow and more reliable plans (Ribeiro et al. 2017). Without a phase schedule, achieving the project objectives becomes a question, since there is no assurance whether the right work is being made ready and executed at the right time. The phase schedule contains a detailed work plan that specifies the hand-offs between the specialists from different departments involved in that particular phase which then turn out to be the goals that should be achieved (Ballard & Howell 2003*b*).

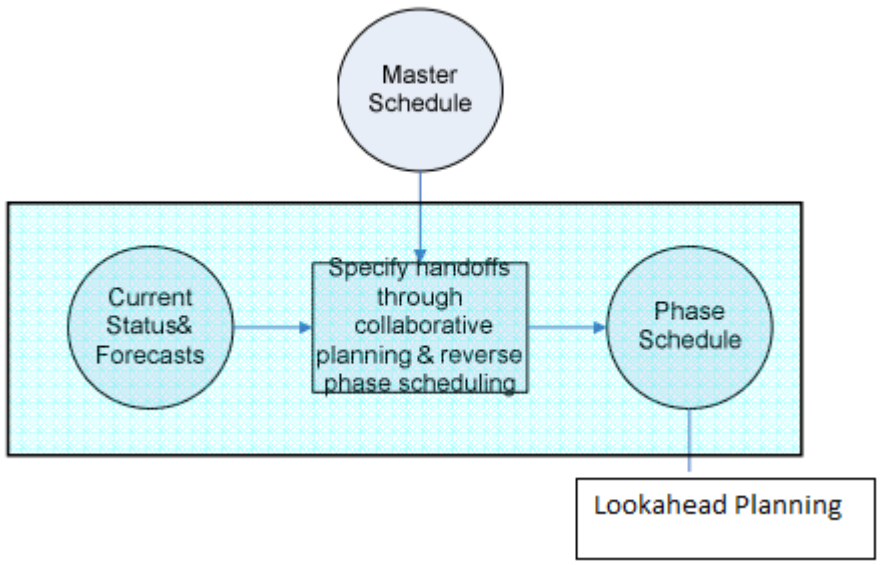

Figure 3.7: Phase Schedule in LPS (Ballard, Hamzeh & Tommelein 2007)

The steps involved during scheduling for a particular phase according to Ballard & Howell (2003*b*), Ballard, Hamzeh & Tommelein (2007), Ballard & Tommelein (2016), Knapp et al. (2006) are :

- The project team for that phase get together in a room where each one writes down their work to be performed which in turn releases work to the next one in the list. These papers are stuck in the wall and they moved forwards and backwards until a logical sequence of activities is obtained. These "stickies" are placed, on the wall or a long piece of paper, moved around to reflect the way the work will actually be performed, discussed, adjusted, until finally a logic network is available. Once a logical connection is identified, the team adds/reduces resources finding the right combination for the whole phase thus finding the duration for the entire phase. Then the duration for each activity involved in the particular phase is calculated.

- The schedule is then re-examined by the team for checking the logical connections and the team then makes a decision on the time that is going to be spent for the activities where they have two choices. One is to assign more time to tasks that are more uncertain and duration of which can be varying. Second one where the start of certain activities can be delayed to give more time for the prior activities to be completed

- This is the final step in creating a phase schedule, where activities are sequenced with logical connections, practical duration correlated with the identified milestone for the phase.

The purpose of a phase schedule is to maximize the value generation by producing a complete plan for the whole phase, so that everyone involved in the phase understand and support it. With the help of phase scheduling is that schedule contingency needs to be deliberately quantified and allocated (Ballard & Howell 2003*b*, Ballard, Hamzeh & Tommelein 2007).

The participants include all the people involved in the activities of that particular phase. For example, a team that is about to create a schedule for a construction phase would typically involve the general contractor and subcontractors, and perhaps stake-

holders such as designers, client, and regulatory agencies (Ballard & Howell 2003*b*, Ballard, Hamzeh & Tommelein 2007). There is no single person or staff role best suited to run the session – it depends on team chemistry and who knows the most about what work needs to be done in the selected phase or can best manage the process (Knapp et al. 2006).

Collaborative Design of Operations in Phase planning:
Last planner system includes social processes such as the collaborative planning as it promotes the participation of all the participants involved in that phase, till the last mile person in order to schedule the work (Seppänen et al. 2010). Planning in LPS does not provide inputs to other processes, but it directly drives the execution. Front line supervisors are the ones who have a good knowledge about the execution of work within a given environment. This process of collaborative design of operations involves the last planners and the craft workers who are high level supervisors and specialists in various departments like quality, safety, logistics, equipment's etc. Collaborative design is very important during the phase planning as it involves planning for a longer duration and this information is very important while planning in detail for shorter durations. (Ballard & Tommelein 2016)

Once the foundation is set clear for phase scheduling by preparing a well structured master schedule, the phase scheduling process incorporates pull planning, where milestones are identified and activities under each milestone are pulled back from their end date to start date. Project teams get a better understanding of the project through better detailing of activities giving them practical durations, better coordination, better knowledge about the work to be released for the next person. All these elements in the phase planning process leads now to a very good baseline for preparing the lookahead plans which looks at a different time frame.

Lookahead Planning - Make ready process, constraint analysis and Workable backlog

Lookahead planning, being an indermediate stage in the planning process acts as a vital link between front end planning and weekly work planning (Ballard 2000*b*). The

tasks in the master plan and phase plan are broken down into the level of operations and these operations are designed for the nearest future, considering the actual resources and prerequisites available for those operations (Chua et al. 1999). Lookahead planning is a critical tool for efficient and effective planning of construction activities. Through the lookahead plan wastes that are generated from activities namely rework, idle time, improper mobilization of resources etc. can be reduced. When resources are checked for their availability prior to the execution of tasks, lookahead plans ensures that tasks can be executed as planned (Ballard 1997, Hamzeh 2009, Hamzeh, Ballard & Tommelein 2012, Al Hattab et al. 2014).

Lookahead planning has a detailed procedural outline, but three main steps involved in the Lookahead planning according to Ballard (1997), Hamzeh (2009) are as follows:

- Tasks are broken down into processes and processes are broken down into operations.
- Constraint analysis and removal in order to make the tasks ready for execution. This process is called the make ready process.
- Perform first run studies and design operations according to that.

This idea of lookahead planning is beneficial just because the thinking ahead of activities is more effective (Ballard 1997) . A lookahead plan does not have a particular timeframe, as it can vary depending on the context and the type of work performed. The most commonly used time frame for a lookahead plan is 6 week or 8 weeks, but the actual timeframe ranges from 3 week to 12 week. Factors like project characteristics, the reliability of the planning system, and the lead times for acquiring information, materials, labour, and equipment has its say in deciding the timeframe for a lookahead plan (Ballard 2000*b*). One other factor that decides the time frame of a lookahead window is the maximum time taken to resolve a constraint for an activity, be it 2 weeks or 6 weeks. This plan consists of activities that are broken down into the level of operations after which the constraints for each and every activity are identified. The operations are designed after identifying the constraints and the last step is where the assignments are made ready (Ballard 1997, Hamzeh 2009, Hamzeh, Ballard & Tommelein 2012)..

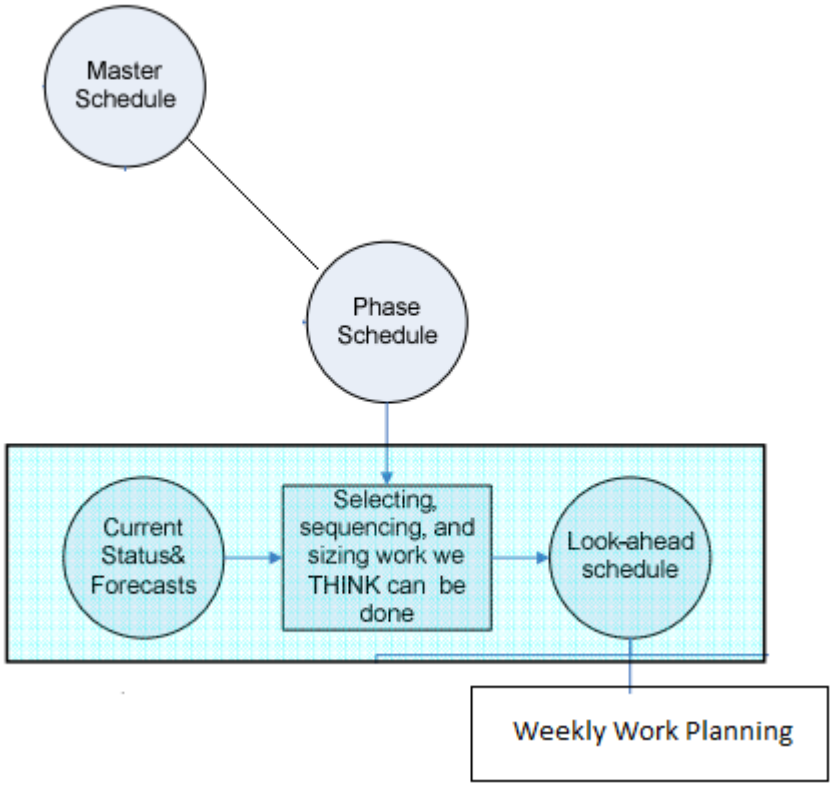

Figure 3.8: Lookahead Plan in LPS (Ballard, Hamzeh & Tommelein 2007)

Procedure of Lookahead Planning

Latest guidelines for lookahead planning have been suggested by Hamzeh, Ballard & Tommelein (2012) and these were build based on the previous work laid out by Ballard (1997), Tommelein & Ballard (1997), Ballard (2000*b*), Ballard & Howell (2003*b*), Hamzeh et al. (2008). These guidelines take lookahead planning a step forward to improve the reliability of the planning and incorporate metrics to assess performance of the system.

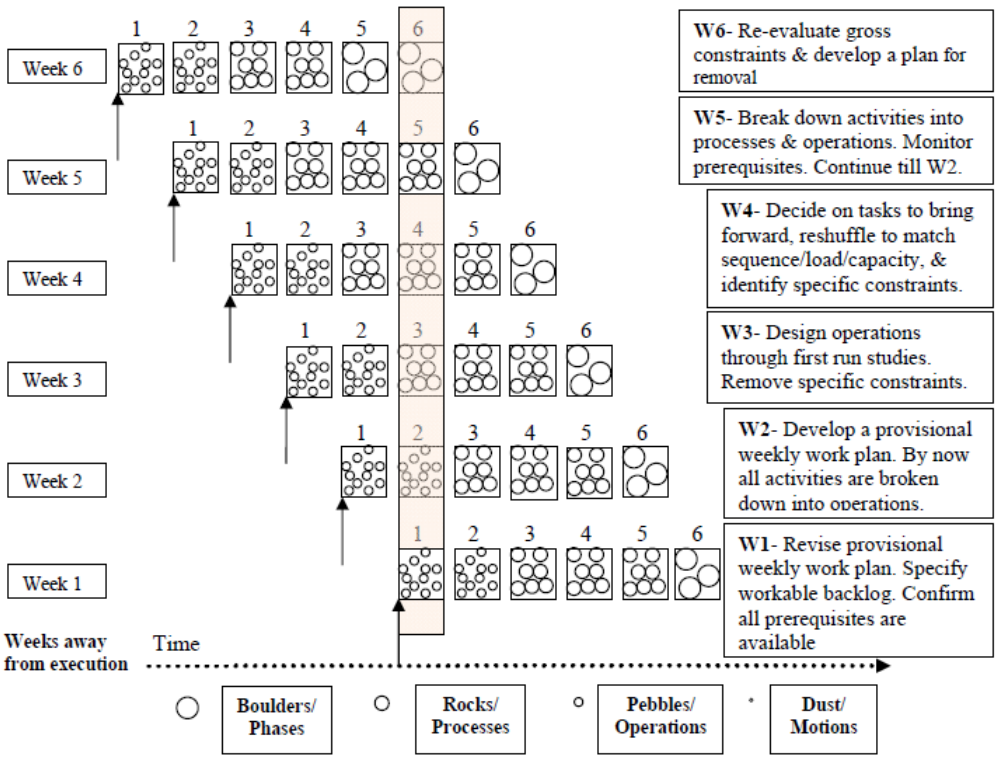

Figure 3.9: Changes made in the Lookahead Plan (Hamzeh, Ballard & Tommelein 2012)

The Figure represents the different phases of a lookahead plan right from 6 weeks ahead of the execution of the activities till the activities are actually executed. The following steps are the reinforcements suggested by Hamzeh, Ballard & Tommelein (2012), Hamzeh et al. (2008) for improving the reliability of a lookahead plan

- Step 1- Time frame is set as 6 weeks ahead of execution and tasks from phase schedule are evaluated for gross constraints and methods are established to remove those constraints. Gross constraints are related to materials and design information and it is recommended to remove these constraints at least 2 weeks before the execution (Ballard 2000*b*, Hamzeh 2009).

- Step 2- Four to five weeks ahead of execution,activities are broken down into steps from the phase level tasks. The steps are assigned correspondingly to the sub-teams or individuals. Simultaneously, for the other tasks, operations are defined, coordinated with the stakeholders and are analyzed for its soundness and the work is sequenced in an optimal manner (Ballard 2000*b*, Hamzeh 2009).

- Step 3- Three weeks ahead of execution, the operations are designed by the teams using first run studies and the operations with unresolved constraints are screened out (Ballard 2000*b*, Hamzeh et al. 2008).

- Step 4- Two weeks ahead of execution, high of detailing is done for the steps and it is controlled by the front line supervisor a.k.a "The Last Planner". Detailing of steps is done like a weekly work plan and these steps will be expressed as tasks that should be performed by specific crew. Constraint-free tasks follow the back on work list as it is ready to be executed once extra capacity is available (Ballard 2000*b*, Hamzeh 2009).

- Step 5- During the last week before execution, a provisional weekly work plan is prepared, from which the quality of the tasks are evaluated. At the end, the weekly work plan consists of tasks that are already ready or that can be made ready in the upcoming week within available capacity. The non-critical tasks will be performed in case of extra capacity and are placed on the fall back work list (Ballard 2000*b*, Hamzeh 2009, Hamzeh, Ballard & Tommelein 2012)

Purposes of Lookahead Planning (Ballard 1997, 2000*b*):

1. To shape the work flow in order to achieve the project objective in the best possible sequence.

2. To improve the workflow by matching labor to the related resources.

3. To maintain a backlog of assignments for the frontline supervisors and the crews.

4. To group the works together that are highly interdependent and use work method for planning the operations.

Not only it does help in removing constraints or making a process ready, but lookahead plan acts a key element in getting out the best possible sequence of activities and also yielding a backlog of activities that are workable. This is called the workable backlog (Ballard 2000*b*, Hamzeh, Ballard & Tommelein 2012) . In the below section, how the operations are made ready for execution where certain activities like producing workable backlogs and analysis of constraints play a big role. This is called the make ready process comprises a major part in lookahead planning.

Make ready process and Constraint analysis

Figure 3.10 illustrates the make ready process and the process itself is explained in detail below the figure.

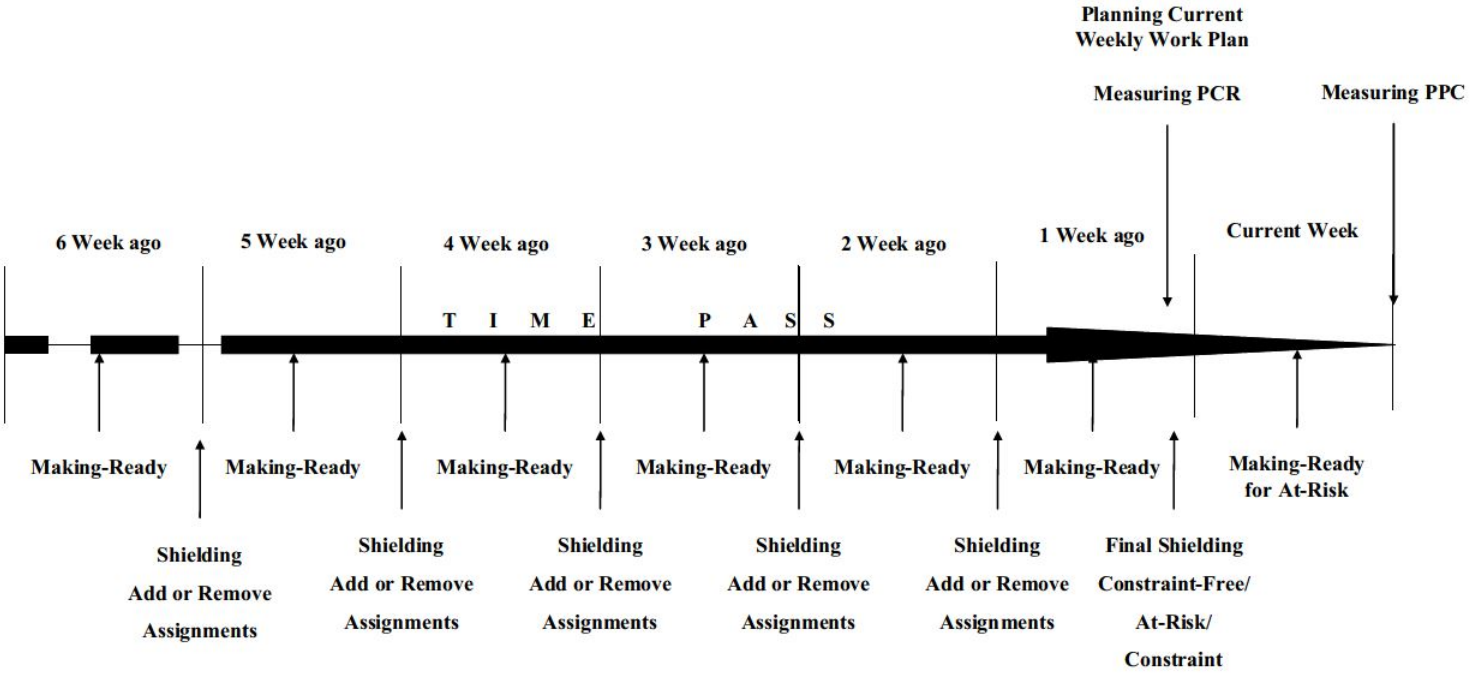

Figure 3.10: Make ready process (Jang & Kim 2008)

"Make ready process" plays a big role in the ability of a project team to make things happen as planned. By making a process ready, it is made sure that all the constraints are identified and removed beforehand. The primary purpose of a make ready process is to produce assignments that are sound and that are in sequence such that the labour and other available resources can be matched corresponding to the available work (Ballard 1997, Ballard & Howell 1998). Ballard (1997) lists down the steps for performing the “make ready” process:

- Developing a lookahead schedule with a timeframe of around 2-6 week. This schedule should be based on the master and phase schedules, with more information.

- Analyze Constraints: This is to make sure that the activities that have been scheduled in the lookahead window are constraint free when they are to be executed. When tasks are broken down to operations, the requirements and prerequisites for these operations can be identified in the form of constraints. Once identified, these constraints should be analyzed based on its status for example, status of design, availability of materials and equipment’s needed for each operation. Based on its status, a timeframe should be fixed for resolving these constraints such that it does not affect the operations during the time of its execution. This process is explained in detail under 3.2.4.

- Develop Action Items: Action items here refer to the appropriate resources needed to resolve the constraints and make ready the assignments. These action items are considered as requests, requested to the ones responsible for removing the constraints. Responses should be about the removal of constraints, whether now or if not when.

- Once the processes are made ready, a weekly work plan should be developed for the activities that are to be executed that particular week depending of labor and materials. Now, a workable backlog is made ready here where lower priority activities are listed in order to have backup activities in case if things don’t go as planned.

- Track PPC and analyze plan failures. The effectiveness of the weekly plan-

ning process is measured with PPC—that is the percent of weekly activities completed 100% as planned. PPC failures may be because of plan failures (constraint not identified or not removed) or execution failures.

To be precise, make ready process and constraint analysis are not two different processes. Make Ready process is one of the components of a Lookahed planning which is used in order to Shield the workers (produce quality assignments with right sequence with the help of constraint analysis) and constraint analysis is one of the components under make ready process which is used to identify constraints for each and every activity under the lookahead plan and remove those constraints before execution of that activity, as mentioned in point no.2 above. The small section below, was written with the motive in order to get a deeper insight about constraint analysis and removal, which is a part of the make ready process.

Constraint analysis and removal

Constraints in a construction project can be physical (ex. availability of resources) or informational (ex. design and drawing details). Constraints can be identified throughout the project, irrespective of the phase and it is the joint responsibility of the team members to remove those constraints (Ballard & Tommelein 2016). Constraint analysis is primarily used to identify and remove constraints such that the uncertainty surrounding before the execution of the activity is released (Ballard 2000*b*). Constraint analysis is more systematic in LPS with the help of the lookahed plan. It is recommended that the front line managers do not just try to resolve constraints by themselves, but need to share the information with all the related personnel, increasing the transparency of the process for achieving better results (Kim & Jang 2006).

In identifying and removing constraints, lookahead planning employs activity screening and pullingTommelein & Ballard (1997).

1. Screening subjects tasks to constraint analysis and culls out those with missing prerequisites such as information, material, previous work, manpower, and space.

2. Pulling makes activities ready by removing constraints and ensuring the availability of prerequisites as per actual site demand.

In case an activity has begun without resolving constraints ultimately it leads to generation of wastes for example idleness of the labours that ultimately leads to decrease in productivity (Koskela 2004). This kind of reduction in productivity hurts the motivation of employees as they know they do quite a physically demanding work that cannot be completed (Ronen 1992). These employees when they loose that trust in the system remain silent without voicing out their opinion which is a key aspect of LPS (Nonaka 2008). Decision making is an important aspect in increasing the swiftness of resolving constraints and in order to reduce this the communication time between the site team and the decision making team needs to be shortened (Shohet & Laufer 1991, Hamzeh, Abi Morshed, Jalwan & Saab 2012).

Kemmer et al. (2007) concluded in his reseach that not all problems can be identified and solved during the make ready process and there can be problems that have not been identified during the make ready process suddenly arising during the execution (da CL Alves & Britt n.d.). Constraint analysis should not be something separately done, but should be a part of the lookahead process. In order to resolve constraints, it depends on the department on the kind of constraints they will be able to remove and it is important to identify the departments and individuals responsible for removing each type of constraint. Considering an example, constraints regarding labours can be removed by the construction foreman and for constraints regarding the design information's, it is the responsibility of the design engineers to remove it.

Workable Backlog

While creating a schedule, one of the important question to ask is that, do we have additional quality tasks for back up in case the assignments fail or productivity exceeds more than the expectations?

The answer to the question is given in the form of a workable backlog. Workable backlog has been a new trend in LPS, which provides backup activities while implementing LPS and it can used in two contrasting ways. First one where all the planned

activities have been finished and to utilize the time of the resources activities from workable backlog can be used. Second one where, certain unavoidable constraints interfere in the execution of activities which could be completed and hence to utilize the resources assigned for the non completed activity, a new activity from the workable backlog can be selected. Ballard & Tommelein (2016). However, if doing an assignment from the workable backlog affects the future work negatively then it is better if it remain untouched (Ballard & Howell 1998).

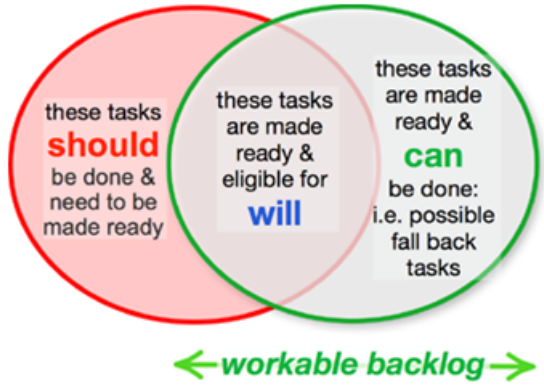

Figure 3.11: Workable Backlog (Ballard, Hamzeh & Tommelein 2007)

The assignments in a workable backlog might not release work as these assignments are not the priority ones and these activities from the workable backlog are to be used only in order to utilize the available resources in case if it's idle and to main the continuity of assignments.

Commitment Planning (Weekly Work Planning (WWP))

The weekly work planning directly drives the production process by showing the inter dependency of work between different specialist trades. This plan is also the most detailed level of plan in LPS. Reliability of this plan is achieved by making reliable promises for quality assignments thus shielding the workers from uncertainty. During the end of each week (the plan period) the reliability of the plan system is measured by reviewing the completeness of the assignments executed for that plan period. Un-

completed assignments are analyzed for their failure reasons so that the same mistake is not be repeated in the upcoming activities (Ballard 2000*b*). The foreman's experience has a lot to say when planning the work for the week, as the foreman who knows the exact situation in ground needs to be precise on what can be done for the week (Dawood 1993, Chan & Hu 2002*a*,*b*, Ko & Wang n.d.). In a weekly work plan, where the production units are assigned specific work and they will be given information regarding the place the work will be performed and the resources they need for that work Tommelein & Ballard (1997)

Ballard & Howell (1998), Tommelein & Ballard (1997) have given guidelines on questioning the assignments that go into the weekly work plan in order to give quality assignments to the crews:

1. Definition : Specific enough assignments for which the resources and man power can be coordinated.

2. Soundness : Workable assignments for which, prerequisite works, design and materials are readily available.

3. Sequence : Assignments that are prioritized based on its soundness and constructability.

4. Size : Assignments or which there is enough manpower force in order to execute them.

5. Learning : In case of failure to execute the assignment, the reasons should be identified.

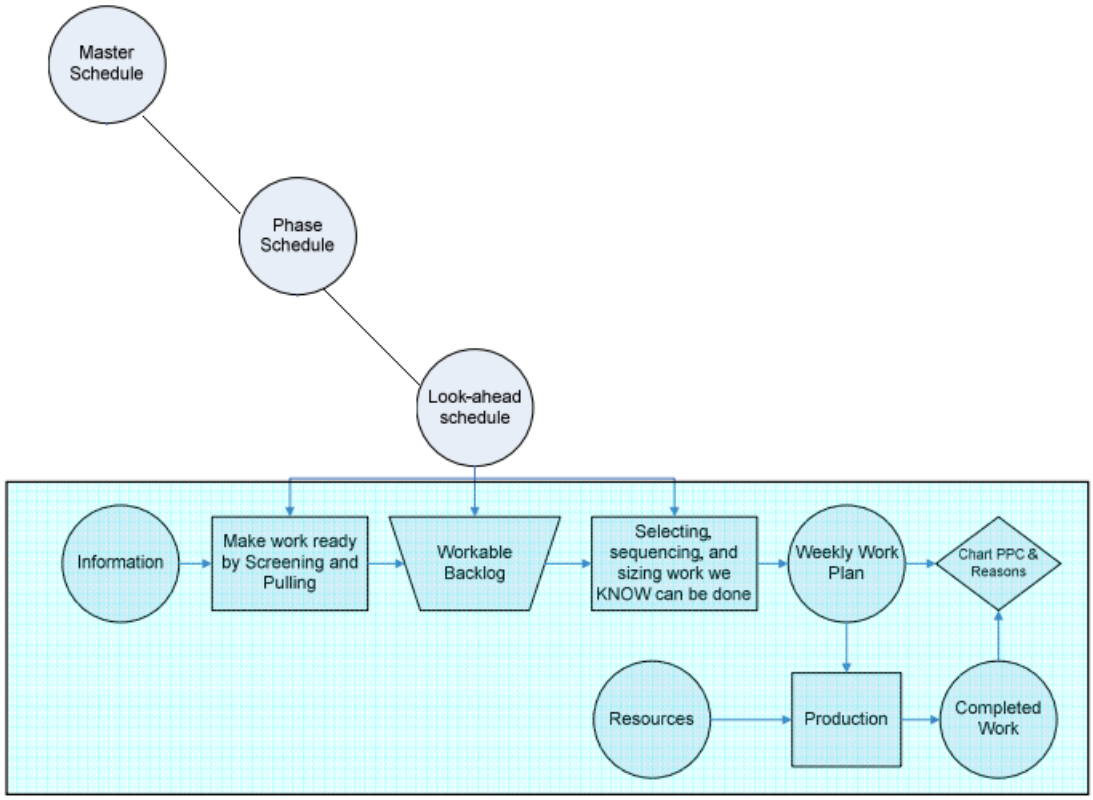

Figure 3.12: Weekly Work Planning (Ballard, Hamzeh & Tommelein 2007)

In the Last Planner system, the word planning means **"To select what SHOULD be done and deciding what WILL be done for a given time frame to complete a project. Not all CAN be done because of constraints"** (Ballard & Howell 1998, Ballard, Hamzeh & Tommelein 2007) :

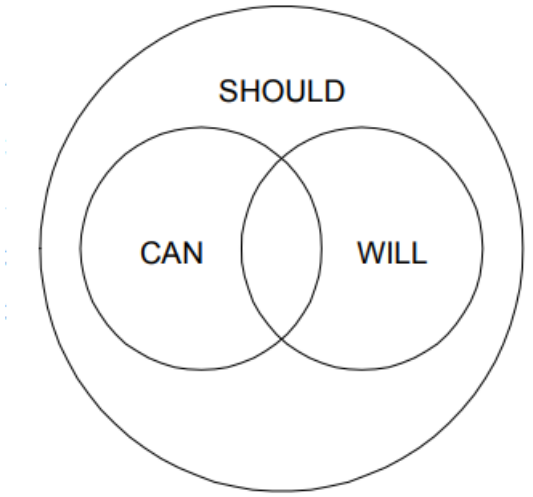

Figure 3.13: SHOULD-CAN-WILL (Ballard, Hamzeh & Tommelein 2007)

Referring to the above figure 3.13, during weekly work planning, the production units need to find out what intersection exists between CAN and WILL, which will be a subset of SHOULD, when they try to execute the plan. The reason is that majority of the construction projects are characterized by CAN and WILL both being subsets of SHOULD (Ballard, Hamzeh & Tommelein 2007).

Out of all the levels in the planning system, the commitments given during the weekly work planning is the starting point in order to create an effective production control system. The activities in the weekly plan are so detailed that it will be used while executing the assignments. In a weekly work planning, promises about the activities that will be completed are given by the project members to each other and in the following week, the efficiency of the number of activities actually executed is measured using a metric called the "Percent Plan Compelete (PPC)" (Ballard 2000). If the activities are not completed as promised, there is a process of recording the reasons for not completing the activities. This process of promising, recording reasons for non completion and measuring PPC is explained below.

Reliable Promising

People come to know that the a person is reliable if he sticks to his promises and start to trust each other (Howell et al. 2004, Macomber & Howell 2004)

"Reliable promises are the result of the commitments we make to each other out of respect for each other's concerns" (Ballard & Tommelein 2016)

The Last planner system prepares participants to make reliable promises, which usually begins through a collaborative pull planning session (Macomber et al. 2005).

When commitments are made it is between the individuals from various departments on and off site and it depends on their capability and the capacity of work that can be done by the individual with the requested timeframe. Once a promise is made, it has to be really concrete. The fundamental principle of reliable promising is that the individuals should be allowed to say "No" upon a request. The last planners cannot make a promise, if they are not allowed to say no. These promises are documented by a variety of ways like constraint logs, weekly work plans etc (Ballard & Tommelein 2016).

Percent Plan complete (PPC)

PPC is recorded to measure the effectiveness of the planning system. Tracking the PPC regularly gives a very good insight about the variations in the project planning, the current status of work and the areas that needed to be given more attention. Previous researches about PPC have confirmed that there PPC, project profit and early completion are directly proportional to each other (Ballard 2000*b*, Bhaidani et al. 2016).

PPC is calculated as the ratio between the number of activities actually completed as per the plan divided by the number of tasks that were actually predicted to be completed (Ballard 2000*b*, 1994). So, a high PPC indicates a better working condition where the contractor has executed most of the activties as planned with the available set of resources, ultimately a better progress in work and higher productivity (Hicham

et al. 2016). Lower PPC on the other hand means there is quite a lot of variation in the work flow and the workers who are last in the chain remain unsure about the work that will be released to them. This implies that the PPC measurements reflects on project performance indicators such as plan reliability, productivity etc. (Liu & Ballard 2008).

From various literature's studied, PPC is the most commonly used LPS metric. This metric is a direct representation to whether the LPS implementation is a success or not, as the increase in PPC suggests that planned activities have been completed to a good extent.

Frequency of Plan Failures

In PPC, there can be tasks that cannot be completed and these tasks are categorized based the cause of failure, say for example "Delay in decisions", "Drawings not available", "Weather" etc. These categories are established during the start of the project in a broad manner depending on the type of the project and it is then refined to fewer categories as the project evolves. A frequency chart is updated and tracked over time visually based on the reason for failures and as time passes by the root causes that have been a problem for completing the activities are identified and the respective countermeasures that have been taken to prevent them from occurring again. (Ballard & Tommelein 2016)

When reasons for non completion (RNC) is recorded, it enables the teams to come together for a discussion about the issues and prevent it's occurrence in the future, thus enabling continuous learning (Ballard 2000*b*). If there no formal action from the management or the site teams for the issues then recording RNC is purely a waste of time and prevents the opportunity for the teams to share knowledge, generate innovation and also improving coordination between project stakeholders. Here formal action refers to a root cause analysis for the issues ultimately leading to the source of the problem (Daniel et al. 2017)

Daily Huddles

Apart from the weekly meeting that takes place regularly in a a last planner system, a daily meeting should be encouraged between the participants within their own work groups. To record or not the commitments made is the decision of the group.Ballard & Howell (2003*b*). A daily huddle is implemented in the form of a meeting between different interdependent groups and discussions are about the commitments each groups have completed and the commitments for which they need help from the other groups. This meeting generally takes place between front line supervisors of design squads and construction crews (Ballard & Tommelein 2016). Based on the negotiations with the rest of the group, each person tells what he intends to do next in a daily huddle meeting. If there are any barriers to the work, it will be announced during the following day meeting (Koskela & Howell 2002).

Organizations must be deliberate in organizing the daily meeting, in order to maintain the commitments made during the plan and also make sure that the commitments are in line with the overall promise to the client (Weigand et al. n.d., Macomber et al. 2005).

Daily huddle meetings have not been incorporated in all the countries that use LPS, as some countries have modified the LPS methodologies according to their convenience. This daily meetings helps both in better coordination between the labours as they get to see and speak with each other at least once a day and it can also be helpful in notifying the constraints that occur at the last moment.

Visual Controls

Visual controls is a management approach used to align an organisation's goal, vision, value, and culture in the workplace through visual stimulation of the stakeholders on the project for continuous process improvement (Tezel et al. 2011). A Visual control system is used in depicting the exact status of the system for all the teams involved in the project in order to develop an understanding between them from which actions can be taken if necessary (Ballard & Tommelein 2016). Visual controls also supports

management practices that are related to safety, performance, production etc. (Tezel et al. 2011). This process creates a better transparency in a project and enables a better communication with the people (dos Santos & Powell 1999, FORMOSO et al. 2002).

According to Valente et al. (2016), Tezel et al. (2013), Moser & Dos Santos (2003), Viana et al. (2014) the effects of using visual controls has quite a lot of positive effects on projects like

1. Better disciplinary activities from the workers
2. Motivate the workers by letting them know more information, and as a result of that they will be able to distribute the information to a variety people, ultimately helping to sight the problems in a very broad manner
3. Achieve a more consistent decision making process and a better clarity of what is expected from the workers.
4. Reducing the extremity of idleness/overloading of teams
5. Ability to make the people remain in a common ground of ideas and information.

Hence the use of visual controls provides relevant measurements (ex. PPC), information that is up-to-date, effective methods used in the site that includes posting simple graphs and charts posted in public places etc. Now given that different components that constitute a Last planner system, there comes a question on what is exactly the role of a last planner in effectively using these components. In the below section it is clearly explained about what does one have to do when one is in the shoes of a last planner.

3.2.5 Role of a Last Planner

In his first paper about The Last Planner System, Glenn Ballard gives the definition for a “last planner”.

“Aside from the simplest and smallest jobs, construction requires planning done by

different people, at different places within the organization, and at different times during the life of a project. Planning high in the organization tends to focus on global objectives and constraints, governing the entire project. These objectives drive lower level planning processes that specify means for achieving those ends. Ultimately, someone (individual or group) decides what physical, specific work will be done tomorrow. I call that type of plans "assignments". They are unique because they drive direct work rather than the production of other plans. The person or group that produces assignments I call the "Last Planner".” (Ballard 1994)

The question of *“WHO IS THE LAST PLANNER?”*is that, the person who manages, oversees, supervises a production unit and who is accountable for the performance of that unit, even involving himself in some of the work. To give some examples, the Last Planner in design may be the design lead, for the general contractor it may be a project engineer or an area superintendent and for the specialty contractor it may be the crew foreman. (Ballard 1994)

According to Ballard and Howell assignments are termed quality only when they are specific, sound, in right sequence and size with all the prerequisites like materials, equipment, drawings, labour, external conditions etc. in place. Once quality assignments are given to the last planner, it is then his responsibility to produce those assignments. With all these information, different stakeholders come together to plan in the most detailed manner called the weekly work plan a.k.a commitment planning. Here different trades are involved where each one gives commitment to one another which means the person will be able to finish the work and also only quality assignments shall be produced. Commitments from the last planner should be really practical as on whether they will be actually able to finish the assignments and these last mile person in the chain should also provide valuable inputs for planning the independent works. Also, the biggest concern of a last planner should be about the work that will be released by him to the next worker in chain because the work of the latter depends on the work of the former (Aslesen & Tommelein 2016).

A last planner can be anyone in a team, irrespective of the trades they are involved in and ideally, each and everyone in a team should be a last planner. It is more about an individual’s ability to understand the concepts and become more skillful related to

LPS, as one cannot become a last planner overnight.

3.2.6 LPS integrated with other Lean Tools

So, the theory presented till this part gives a very deep insight into the last planner system. However, various lean practitioners have identified that Last planner system, when integrated with other lean tools and used in a project, gives way better results than just using LPS. In this part, a detailed explanation on LPS combined with different lean tools such as the Location based management system, TAKT time etc. is given.

Location Based Management System (LBMS)

The usage of LBMS helps in transforming the quantities in various locations, site productivity to reliable duration and also provides a very good vision for predicting the future of the project, thus moving towards the goals of the project (Kenley & Seppänen 2009). It has been identified from recent studies that there is a heavy correlation betwen LBMS metrics and PPC and also that LPS and LBMS have got complementary features, since LBMS can provide the high level tracking that is missing in LPS and LPS can provide the lookahead screening and weekly planning process that is missing in LBMS (Seppänen et al. 2010, 2015, Dave et al. 2016).

Project locations are hierarchy based in LBMS and they are defined by a Location Breakdown structure, similar to a Work breakdown structure in project schedules. In order to plan based of locations, quantities based each location should be a starting point. In order to calculate the duration, first the quantities in each location is divided by the crew size in that location and this is multiplied with a labor consumption factor (Kenley & Seppänen 2009).

In their paper, Dave et al. (2016) have proposed the usage of LBMS complementing the components of LPS.

1. For a master schedule overall LBS (based on building and floor level detail)

should be defined and use the available quantities and productivity information in order to estimate the production rate. The dates achieved in this master plan can be used to identify the phase milestones and they are mainly used to identify the items which have a long lead time.

2. For the identified phase milestones and tasks the LBS should be prepared. For the identified locations and tasks in the phase plan, the quantities and productivity information are collected. First the productivity rates are calculated by only one crew (results in an unaligned production rate) and then a meeting with all the trades involved in phase should be arranged, where production rates are calculated again (results in an aligned production rate). So the changes in production rates calculated from the first and second meetings are recorded as commitments.

3. Updating the weekly progress in LBMS, updates the forecast giving a good idea for prediciting the future and this information should be used in modelling the lookahead plans. The same procedure applies for the weekly work plans.

4. When updating the forecast, the teams can use it to get a better insight on when and how much work should be happening at a particular location. Last planners can also use this information to add more details to the assignments assigned to them and thus committing to the weekly plans. With the available information of planned and actual productivity and production rates, and planned and actual resources, root cause analysis can be performed to detect the source of the problems, preventing it from happening again in the future.

One important thing here is that, if LBMS is incorporated into LPS, then it should be used throughout the planning process. It does not work good if LBMS is just used for a phase schedule or a lookahead plan, as it breaks the continuity of the planning process.

Takt Time

"Takt time is the rate at which the customer demands the product and hence dictating the rate at which production should take place to meet those demands exactly on time without generating unnecessary inventory. It is the heart beat of one piece flow" (Liker 2005). Creating and producing takt time creates a continuous flow, reduces work flow variability by increasing the speed of certain standard activities and hence reduces the duration and cost of the project (Kenley & Seppänen 2009, Linnik et al. 2013). Looking from a construction point of view, the rate which construction processes should move optimally is the takt time (Yassine et al. 2014). Overall, takt time plan provides a new dimension for LPS by standardizing the work.

A study from Frandson et al. (2014) suggest that takt time planning has the ability to complement LPS since it can increase plan reliability, predict the flow of materials and resources across different locations.

There are six steps involved in order to develop a takt time plan according to Frandson et al. (2013). (1) data gathering, (2) zone definition, (3) trade sequence generation, (4) individual trade duration, (5) workflow balancing, and (6) production schedule finalization .

In cases where customer has a flexible demand rate, the production team can create their own demand where and here takt time provides "Beat" which offers two benefits such as providing activities with the right size and sequence to the last planner and a well planned workflow that reduces the pressure off the foreman to release the work to the person next in the line. The lookahead process with the help of takt time plans becomes more simplified with clear batches of work as it initiates more focus to the staffs on their site (Frandson et al. 2014).

In order to develop a common understanding (considered 8th flow in construction apart from Koskela's 7 flows (Pasquire 2012)) on the overall production strategy, takt time plays an effective role by providing opportunities for the production team right from the planners to the foreman to engage with each other and have a common ground. Planning for everyday activities using takt time motivates the workers to have a meeting and set goals for everyday. Apart from the work that is being performed,

takt time gives a good clarity about the work that will be performed next (Frandson et al. 2014).

Now a heavy focus is placed on LPS in India and Norway, since these are the countries under comparison. In this section various attempts by various lean coaches/consultants in India and Norway have been metioned below.

3.2.7 Last Planner System in India

The implementation of the Last Planner system in India is still in the infant stage. There has been quite some implementation of the LPS in construction projects all around India. "Nadhi Information Technologies", one the foremost companies to introduce Lean in India, is professionally implementing the Last planner system in 20 out of their 38 projects. Even though there are a lot of tools under lean construction the main reason for choosing to study only the last planner system is the reason that, this is the only process that has been implemented in a variety of projects in India (Vaidyanathan et al. 2016)

Experiences from the projects, where the last planner system was implemented by the Lean consultants of Nadhi Information technologies, were published as papers in IGLC conferences and also the National conference for Lean construction in India. These published papers were regarding the improvements and experiences gained in the site by using the Last Planner System and some of the key achievements learned from the literature have been mentioned below.

1. In the year 2016, during the construction of a 200,000sq.m IT commercial facility, for a period of 1 year, the LPS was implemented for the civil works. Main processes include the six week lookahead plan, from which WWP was derived and PPC measurements were made daily and weekly. Meetings were held daily morning and also weekly once between owner, Project Management Consultant (PMC), general contractor and fifteen subcontractors. Discussions were about activities for each day, analysis and resolution of constraints, if any. Apart from this, there has been an attempt to integrate the LPS with LBMS (Seppänen et al. 2010). This was during the construction of toilets, where the main aim was to

avoid the ad-hoc movements of the site labours and generation of workfront. There were improvements in the cycle time, where it was planned for 60 days for one toilet, but it was actually finished in 50 days. Also, productivity of the labours increased by 27% (Vaidyanathan et al. 2016).

2. In the year 2013, during the construction of a residential building with seven blocks, the project was running 45 days behind schedule. Phase schedules were revised with the help of the Last Planners (Planning engineers and the subcontractor supervisors), based on which WWP was created and weekly meetings were held to plan the work for next week. PPC was tracked everyday and also every week. Failure reasons were studied which was either due to coordiantion or execution and it was made sure the same failure does not happen again. Site constraints like labours, materials etc. were resovled, which resulted in a drastic improvement in the productivity and the average cycle time reduced from 23 days to 14 days. (Vaidyanathan et al. 2015)

3. In the year 2010, during the constrcution of a 4*300W Thermal power plant in India, where the project value was around $200 million. Lookahead plans were made, constraints were analyzed and main learnings were about the things that works and that does not work in an Indian environment. Problems such as workfront availability, productivity and availability of labours were almost eradicated. Cultural changes in the site include supervisors taking responsibility for the WWP, site team meeting for pre-planning tools and equipments etc. PPC increased from 50 to 70% and the productivity increased by 10% (Vaidyanathan, Nandakumar, Rudra, Raman & Mundoli n.d.).

4. Apart from this, IIT Madras, an educational institution, conducted raining sessions with the help of various Lean practitioners in order to promote the implementation of LPS by the contractors, without the help of a third party consultant. The projects chosen were residential buildings (4), commercial buildings (3), Marine jetty (1) and one for an underground Metro Railway station (1). Trainings were in the form of 3 days workshops, skype meetings, site visits and webinars from June 2013 to February 2014. Outcomes of this training for the site staff include increase in the morale, developments in the planning skills and

innovations with better work methods. At first, organizations were reluctant for a cultural change, but then gradually there was more interest shown, as a result of which 4 out of 9 projects implemented the last Planner system in their projects (Raghavan et al. 2014).

From the previous attempts in India regarding LPS lean coaches have found a way to succeed only in bits and pieces and not with the project as whole, the main reason for that being the lack of experience for the planning engineers and the execution engineers with LPS. This thesis, investigates the reason for this lower level of success by looking into an extra dimension of the "Culture" and identify the cultural reasons that stand as roadblocks for successful LPS implementation.

3.2.8 Last Planner system in Norway

A data from SSB-Statistics Norway shows that productivity in the AEC industry has declined since the 80's and quantitatively after 2000's productivity has fallen by 20%. Surveys from various studies have shown that delays in construction processes are due either wrong or missing production materials from the designers (Knotten & Svalestuen 2000). Hence Norwegian contractors have had long term interests of implementing Lean construction Practices into their project management system (Kalsaas et al. 2009). A Norwegian data envelopment study of 122 comparable apartment block projects have shown that there lies a lot of variations in productivity, some projects with a high productivity and some projects with a lot productivity from the study. However they have concluded that even in projects that has a high productivity, there lies lot of waste generation too. In Norway, Lean Construction is growing in popularity and is by several industry professionals viewed as the project model of tomorrow (Fosse et al. 2014)

The Last Planner System seems to have entered the Norwegian industry around mid-2000s, with predominantly two large contractors incorporating it into their planning and control systems; Veidekke and Skanska (Kalsaas et al. 2009). There are several Industrial practitioners of LPS in Norway and they have their own translations for LPS. The contractors in Norway using LPS are Veidekke (Collaborative Planning),

Kruse Smith (Collaborative Planning), Skanska (Trimmed Construction) and Nymo (Collaborative Project Execution).

There have been several publications regarding the LPS implementions in Norway. Out of those publications some of the significant publications have been briefly explained below:

1. In one of the attempts to implement LPS, it was a rehab project of an 115 year old University building is Ås. It was a 3 storey building with a gross area of 8190 sq.m. The value of the project was around 470 MNOK. Since this project was one of the early attempts to bring LPS in Norway, it did not yield a success rate as expected. Even though pull planning was implemened during the start of the execution, the lack of experience with the lookahead process played a major part leading to poor results. Also, a workable backlog could not be maintained because the participants of the meeting did not prepare anything beforehand. The project management team were not aware of the actual state of the old building and as a result of which it was tough to manage some unforseen challenges. There were complaints on both the client and contractor side that they lacked a motivation to bring the lean culture into the project. There was also a concern about the contract strategy which led to a bad collaboration during the phase planning meetings. (Haarr & Drevland n.d.)

2. This project was a mixture of a kindergarten, junior high school and a sports and cultural centre in an area of 6800 sq.m and Skanska was the general contractor of the project. Reverse Phase scheduling was done with the help of participants including three technical subcontractors (electrical contractor, plumber and sprinkling, and ventilating) and the general contractor (project manager). Milestones for the phase were identified and a brown line was drawn between each identified milestone. Subcontractors identified tasks and wrote them on paper with the expected lead time through reverse pull planning. Tasks identified were stuck on the wall in the tight sequence. Lookahead plans were made for 3 weeks and it was observed that the output from lookahead plans were not used in the weekly work plan meetings to create a workflow and a workable backlog. This has been the major drawback in the implementation where outputs from

different sessions have not been linked which led to a bad constraint analysis. One major success was the involvement of the technical subcontractors in the planning process as they were identified to be collective and organized. However, there was a bad coordination between the architect, general contractor and the owner (Kalsaas et al. 2009).

The above presented are just 2 cases amogst various cases identified from the literature. This is just to show that Norwegian contractors have had both success and failures with their LPS system. Ultimately it is certain that Norwegian contractors are well versed with the LPS phenomenon, as several major Norwegian contractors have incorporated LPS into their project management system, with different names. This indicates a better awareness of the contractors with LPS as they believe that LPS brings a positive change in their system as it provides an environment where employees are able to create better plans, be it a master schedule or a detailed weekly work plan.

It was mentioned at the beginning of the study that, there will be a cultural comparison for both the countries in order to identify the enablers and roadblocks for successful implementation of LPS. However, it is first necessary to understand about the factors that affect knowledge sharing between the employees as knowledge sharing plays a significant role regarding the coordination between employees.

3.3 Role of Culture in LPS

3.3.1 Knowledge sharing Barriers and techniques to overcome them

Knowledge sharing is nothing but, individuals/teams who are aware of the difficulties faced by the other individuals/teams share their valuable knowledge to help see their own situation in a better perspective (McDermott 2000). Knowledge sharing between teams working in a project is key for construction processes as it involves people

from different backgrounds, motivations etc. and it forms the base for knowledge creation, innovation and learning between teams. From a series of recent studies, various barriers that have prevented effective knowledge sharing has been identified namely organizational culture, national culture, issue of trust amongst employees etc. (Riege 2005, 2007).

The different barriers according to (Riege 2005, 2007) are explained in detail below.

- Knowledge sharing barriers at an individual level can be because of factors like poor communication skill of the individual, national culture of an individual and sometimes because of the lack of trust towards a co-employee.

- Looking at an organizational level, factors affecting knowledge sharing are poor infrastructure of the organization, economic growth of the organization and most importantly the physical environment inside the organization.

- Apart from the above mentioned two barriers, knowledge sharing is affected to a significant extent by the national culture of individuals. This is because of the values, beliefs and practices followed by individuals from each nationality. Several empirical studies about national cultures have given conclusions that several asian and european countries reflect to mistakes in a positive manner, believing that it helps them grow better both as an organization and as an individual in the organization. There are also certain cultures where employees still hesitate to share knowledge, thinking it might reduce their job security.

Studies have also recommended some solutions for eliminating the barriers like better motivation at the employee level by the organization, flat organizational structures enabling a better communication between higher management and employees resulting in a faster decision making process, organization promoting continuous learning by providing valuable feedback to the employees and better use of technology which provides access to knowledge from both internal and external sources (Riege 2005, 2007).

However, solutions to overcome this knowledge sharing barrier have been too much generic as lean consultants find it hard to overcome very specific barriers through

these generic solutions. This thesis paves a way for that not just identifying general problems faced by lean consultants, but identifies cultural problems that are very specific to India and Norway. Also in this thesis, the problems identified and the solutions given for those problems are specific to LPS. Now that national culture acts a big roadblock for successful knowledge sharing, a study about the culture of the nations, India and Norway was undertaken. Also, a study from Johansen & Porter (2003) reveals that cultural barriers like attitude to work have a say when LPS is implemented. In an attempt to get a better insight in this statement, the author has studied a cultural assessment field called Hofstede's cultural dimensions theory. This Hofstede's cultural dimensions (Hofstede 1984) has been selected as the theoretical base and the national cultures are analyzed based on Hofstede's study of different national cultures.

3.3.2 Hofstede's cultural dimensions

Hofstede is perhaps more known in fields such as sociology and psychology than engineering, but the authors argue that with culture and people being such a strong proponent of Lean practices, such cultural analysis tools could provide valuable insights into factors of success or failure of certain practices in certain cultural conditions. To help understand the difference between the cultures of countries, such as Norway and India, Hofstede looks to score them within six so-called cultural dimensions.

1. Power Distance is "the extent to which a society accepts the fact that distribution of power in institutions and organizations is unequal" (Hofstede 1980).

2. Individualism is "the degree to which people in a country prefer to act as individuals rather than being a member of a group" (Hofstede 1994).

3. Masculinity is "the extent to which the dominant values in a society are related to their assertiveness, acquisition of money and things" (Hofstede 1980).

4. Uncertainty avoidance is "the extent to which a society tolerates ambiguous situations and tries to avoid these situations by establishing more formal rules and believing in absolute truths" (Hofstede 1980).

5. Long-term orientation is "the ability of a society to connect the past with the current and future challenges" (Hofstede 2011).

6. Finally, Indulgence is "the extent to which a society allows relatively free gratification of basic human desires related to enjoying life and having fun" (Hofstede 2011).

Hofstede's cultural dimensions has it's own disadvantages according to *Clearly Cultural* (n.d.)

1. It presumes the whole population is equal, but not all sub-cultures and individuals necessarily fit into it.

2. Nevertheless, the data collected is important as long as the context and content of the questions is phrased in the right manner.

3. Also, with the various technological advancements, nations have shown significant changes in their economy over the years indicating that people are getting up to date. Hence this study does not have data that is up to date

4. Apart from this critics have also claimed that this model does not capture the complete phenomenon, as culture has more than six dimensions (Chao & Moon 2005).

It has been assumed in this study that, hofstede analysis would be a good tool for finding out the cultural reasons behind the limited usage of various LPS components in India and Norway. However, as mentioned in limitations in chapter 1, this analysis does not provide a solution for these cultural problems. Based on the literature's studied regarding the culture of India and Norway and also with the results of Hofstede's cultural analysis between both the countries, the author has made an attempt to answer the third research question i.e. potential improvements for the future considering the cultural aspects.

Chapter 4

Findings & Discussion

A summary from the case studies and interviews regarding the three research questions are presented below. They are then compared with the findings from the literature.

4.1 LPS implementation in India and Norway

4.1.1 India

In this section, the findings from the case study and interviews are discussed. In the Indian construction environment, Last planner system is not a common phenomenon in all the projects. It depends on the problem statement from the customer, from which it is decided to implement either last planner system or other kind of lean tools. Other kind of lean tools refers to Value stream mapping, Work sampling etc. in case of problems like activities getting delayed and less productivity in the site (Ramakrishnan Ravi, 2017).

The Institute of Lean Construction Excellence, India (ILCE) has been creating a basic awareness of lean amongst both mid managers and top executives over the past few years through seminars, workshops, education and running local chapters. There are

high expectations on the results from lean and what it can achieve for projects (in terms or bringing delayed projects back on track and eliminating cost overruns). The need for LPS is felt a few months into project execution, when conventional approach has led to delays. There is pressure to bring the project(s) back on track. A third party lean consultant is hired to introduce the lean construction techniques (including LPS), does the site observations to understand the current condition of the project, report the "as-is" situation and a "to-be" intervention plan to the higher management. Hence, planning is not done by someone at the office, rather the last planner i.e. the person who executes the activities (as he has more information about the exact situation in the site) is involved in the planning and a confirmation should be given by him whether the activities that have been planned can be executed or not. The Lean initiative is often kicked off at the site with awareness workshops and possibly simulation games (e.g. the parade of trade game) (Tommelein et al. 1999). Then, the expectations from the site going forward is set by the third party consultant.

From the cases studied, the main objectives of introducing LPS in construction projects in India, have been identified in the pilot study of the thesis (Ramakrishnan Ravi, 2017). They are:

1. To make assignments to workers through continuous learning and corrective action and to cause the work to flow across production units.

2. LPS focuses on making a rolling look ahead schedule from a milestone plan that captures the overall project schedule. The work backlog generated from the look ahead schedule is used to derive detailed weekly plans in discussion with the last planners based on the current situation on the ground.

3. Finally, the performance of the weekly plan is rolled up to ensure that the milestones are being adhered to and the non-performance of the weekly plan is used as a learning to improve the productivity, coordination and execution of the project.

From the three case studies and four interviews with Lean coaches from India, a typical approach to implementing LPS in India is as follows:

1. The planning sessions are first started by preparing the phase schedule identifying the milestone activities from the master schedule that will be received from the contractors. All the trades involved in the whole phase participate for the meeting and activities are pull reverse from their end date to their start date. For example, a phase that was planned in one of the cases was "Mechanical-Electrical-Plumbing (MEP) Works". This schedule is called as the Level 2 schedule by lean coaches in India, where as the master schedule is called the Level 1 schedule with the lowest level of detailing. This phase schedule prepared, forms the baseline for preparing a lookahead plan.

2. The next meeting session is for the lookahead planning. Since lookahead timeframes varies consistently from project to project, Indian lean consultants employ the technique of identifying a lookahead timeframe from the maximum time taken by the workers to resolve the identified constraints. Once timframe is identified, a meeting is fixed involving all the trades for that particular timeframe. From the three cases studied, two cases used a lookahead timeframe of 6-8 weeks and the remaining one used 5-9 weeks. This lookahead plan is called the Level 3 schedule. As a part of lookahead planning meetings, the constraint analysis is done and the workable backlog is prepared.

3. Once a lookahead plan is done, teams start planning in detail for each week which is the weekly work plan. For creating these plans a meeting takes place at the start of every week with the involvement of stakeholders like execution team, contractor side staff, subcontractors, client side staff, PMC of that project and the third party lean consultant. The stakeholders for these meetings does not remain the same throughout the project, as the subcontractors might change based on the activities for a particular week. Teams then sit every week to plan for the upcoming week, where commitments will be made to each other. At the end of the week PPC measurements would be done in order for the teams to know how well they have stood up for their commitments. If any failures, reasons are noted and are reflected upon in order to not repeat them in the future.

4. In addition to these meetings, Indian lean coaches have added a Daily standup meeting in site for about 20 minutes to plan for the day and at the end of the day

PPC is measured for the day. LPS theories have not mentioned about measuring PPC on a daily basis but the Indian lean consultants have started this new practice of measuring PPC on a daily basis.

5. The Indian lean coaches have recommended the contractors to use the visual management system to a great extent and it took quite some time for the contractors to accept it. From the cases all the projects had a "BIG ROOM", where all the meetings take place and where all the visual controls are presented. Lookahead plans and the weekly plans are the main ones to be visually represented. If any constraints, responsible labour posts stickies in the wall on that activity leading to the person responsible for resolving that constraint.

With the given structure for LPS meetings, projects in India start up with identifying milestones from a master schedule from which various phases are identified for the project for which phase planning meetings take place and in a phase various lookahead planning meetings take place based on the lookahead timeframes and in a lookahead timeframe, a weekly work plan meeting takes place at the start of each week.

4.1.2 Norway

From the case studies it was evident that the two major contractors in Norway - Veidekke Entreprenør and Skanska Norway – have LPS built into their project management systems. One reason of analyzing the LPS strategies of two different companies is to figure out the degree of similarity between them and the strategical differences in their system. This was also because each and every project of both the contractors has been integrated with LPS and the projects were easily accessible with the help of lean coaches from both the contractors.

Veidekke

Veidekke has been using this system to a great extent from the year 2006 (Fundli & Drevland 2014). Before the implementation of LPS on site, Veidekke has an introductory course at the beginning for employees, where everyone goes through four

modules namely strategic planning- master and phase scheduling, Lookahead planning, Legal binding plans, making commitments and Weekly and Daily planning.

- Regarding the meeting structure of Veidekke it all starts with the phase scheduling meetings for foundation, structural and finishing works of buildings (these were the 3 different phases identified from one of the case project).

- Looking on a weekly basis, Veidekke has four planning meetings every week with different stakeholders involved for each meeting. All the three cases that were studied had the same meeting structure. The first meeting is on Monday, participated by the subcontractors to plan their weekly work and the workforce they need. Each team will be given an exact number of tasks that will be executed by them for the week.

- The second meeting is on Tuesday and this is a lookahead planning meeting with a time frame of 2-4 weeks. Veidekke have their own strategies for setting the timeframes for lookahead plans. The foreman and subcontractors will be involved in this meeting.

- The third meeting is on Wednesday which is also a lookahead plan meeting, but this one looking at a longer timeframe of 5-9 weeks. The site manager and project manager are the ones involved in this meeting. This meeting is held in order to discuss the status regarding information like drawings, labour force, equipment as some equipment's that are needed to be ordered in advance. The make ready process is used here and for making work ready by constraint analysis and preparing the workable backlog. Also, they have an MS Project schedule linking every activity to each of the pre-requisites mentioned above and a YES/NO column, whereas only activities with YES on all seven are ready to be included on the weekly work plan. If there is a problem regarding any of the pre-requisites, someone is made responsible for removing the constraints by Friday of that week.

- The fourth meeting is on Friday, where all subcontractors meet the foreman, discussing about the work done for the week and also planning work for next week. If a planned activity has not been done it will be moved to the next week

as a part of workable backlog. This Friday meetings is used to measure the weekly PPC and the recording the reasons for not completing the activities as promised. Veidekke doesn't employ the daily standup meeting practice and also meauring PPC on a daily basis.

- Veidekke have the practice of sticking notes on the wall for two of their plans. One for the 5-9 week lookahead plan and one for the weekly work plan. Veidekke does not use visual management in all their projects, but only when they have a lot of constraints to deal with. Out of 3 cases only 2 case project from Veidekke have used the Visual management system.

Skanska

Looking at Skanksa on the other hand they have the same kind of introductory courses and training like Veidekke at the beginning of the project. Skanska also identifies the different phases to be scheduled from the master plan. However, they have a slightly different meeting structure than Veidekke.

Usually they have three planning meetings per week for production work.

- The first meeting is on Monday involving participants from all the trades who have activities that week and this meeting is held in order to plan the work for the week.

- The other meeting is on Friday and the participation of Foreman is considered to be very important for this meeting, as the Skanska lean coach from his interview considers this meeting an opportunity for the foremen to coordinate with each other. In the same meeting, the PPC is for the week is measured and reasons for non completion is also noted.

- Skanska's lean coach refer the lookahead planning as Production-Procurement-Design meeting. Skanska has a PPD coordination meeting for the in-house managers. This meeting is to identify the activities for the next 5-9 weeks and identify if any material or resources need to be ordered in advance. Skanska also takes initiatives to improve the coordination between project teams, not

just subcontractors and foreman, but even the higher management by arranging activities outside workplace. This is a general initiative by Skanska and it is not project specific.

- In addition to these mandatory meetings, Skanska also have a daily job briefing, where each crew involved for the particular day have a final review of their daily tasks, which helps them to coordinate with other trades if they are waiting for a release of work from another team. Skanska's most of the projects plan their on-site activities location-based in their pull-planning sessions as a part of LPS in their system.

- The interview with Skanksa's lean coach revealed that they use the constraint analysis during their PPD meeting and preparing the workable backlog to a great extent in their LPS system. This was because they don't have the practice of make ready process but just a PPD meeting from which they are able to solve all their issues and plan the exact amount of work way in advance. The lean coach proudly expressed his view that Skanska's planning engineers are able to plan the right amount of work at the right time neither too early nor too late. So they were not pushed into a situation where they need to find a replacement activity if anything goes bad or a new activity if they have finished all the activities. The visual management in Skanska's LPS system were not used to a great extent too. They employ this only when they feel they run too much behind the schedule and when they have a lot of constraints, which is "very rare" as said by the lean coach. As identified from the case studies only 2 out of 3 projects employed this technique.

The above mentioned are the findings about the methodological implementation of LPS in India and Norway. Here, a main difference is that the Indian projects bring in LPS with the help of a third party consultant only if they have problems in the project, whereas Norwegian contractors have incorporated LPS in their project management system, which shows that they are more dominant and well aware than India. This situation shows that planning engineers employed by the contractors have a basic knowledge about LPS, whereas Indian contractors do not have that precondition of LPS knowledge while employing their planning engineers.

The Indian approach is more of a textbook style, following exactly what is mentioned in the theory of LPS, creating a master schedule, phase schedule, 6-8 week lookahead plans (as identified from 2 out of 3 cases), a weekly work plan and at the end complemented well by the daily planning meetings too. Veidekke and Skanska from Norway have a bit contrasting methodology of implementation than the Indian style because of the fact that Norwegian contractors have been using LPS for quite a long time. On comparing these two Norwegian contractors, they have a similar conceptualization and implementation of LPS, expect for their meeting structure. Employees get central training in LPS, as well as project-specific support during execution. Skanska's planning hierarchies follows the theoretical prescriptions for LPS with master and phase scheduling, 5-9 week lookahead planning (from all the 3 cases studied fotm Skanska), making commitments, weekly and daily planning, tracking of progress and learning. Veidekke's planning hierarchies have been modified to some extent from the theories as they do not employ a daily standup meeting and also they have 2 different lookahead planning meetings, one for 2-4 weeks and the other one for 5-9 weeks. An interesting finding between the Norwegian contractors was that Veidekke has four meetings a week and on the other hand skanska has three per week showing a bit of contrast between the Norwegian contractors themselves. Apart from the meetings structure, the methods used for schedule creation be it a phase or lookahead plan the procedure remains the same. The additional meetings in Veidekke for each week is for the purpose of increasing the coordination between the subcontractors, as Veidekke's lean coach expressed his concern about subcontractors in Norway not having a good awareness about LPS and lacking a bit coordination with other subcontractors. A similarity is that, both Indian and Norwegian projects have practiced the process of measuring PPC every week. India have gone a bit further measuring PPC for every day. This practice was employed in India in order to increase the motivation of the foreman since they felt the ownership of the plans as identified from one of the cases.

4.1.3 Literature and Practical implementations

With the available information, another attempt was made to validate things that have been mentioned in the literature. This table shows the practical implementation from

the Indian and Norwegian projects and the theoretical basis regarding the implementation of those LPS components. This table also identifies the similarities and differences between the Indian and Norwegian LPS practices.

Table 4.1: Theoretical vs Practical implementation in India and Norway

Theoretical Background	India	Norway	Similar/Different Practice between countries
Phase scheduling: The purpose of a phase schedule is to maximize the value generation by producing a complete plan for the whole phase, so that everyone involved in the phase understand and support it. (Ballard & Howell 2003*b*)	Phase schedule is made at the start by identifying the contractual milestones, which is then broken down into lookahead plans, weekly plans and daily plans with the coordination of all the teams involved in that phase.	Veidekke and Skanska also identify the phases at the start using the master schedule	Similar

Theoretical Background	India	Norway	Similar/Different Practice between countries
Purposes of lookahead plan (Ballard 1997) 1. To improve the workflow by matching labor to the related resources. 2. To maintain a backlog of assignments for the frontline supervisors and the crews	A rolling 6-week lookahead plan is made, which can used for the comparison of what is the current status of the project and how well is the project moving towards its completion.	The purpose remains the same, but the timeframe differs. Skanska uses the PPD coordination meeting as the lookahead planning meeting. Veidekke does has a short term (2-4 weeks) and a long term (5-9 weeks) lookahead planning meeting.	Different
Purposes of weekly work plan: The commitment planning is executed with the help of a weekly work plan, where the production units are assigned specific work and they will be given information regarding the place the work will be performed and the resources they need for that work. (Tommelein & Ballard 1997)	Weekly plan is rolled up to ensure that the milestones are being adhered to and the non-performance of the weekly plan is used as a learning to improve the productivity, coordination and execution of the project.	In both Veidekke and Skanska subcontractors and foreman meet on Friday of the week to plan work for the next week. Skanska considers this meeting important for coordination between foreman.	Similar

Theoretical Background	India	Norway	Similar/Different Practice between countries
Commitments and promises :The Last planner system prepares the participants to make reliable promises, which usually begins through a collaborative pull planning session. (Macomber et al. 2005) PPC: PPC is calculated in order to measure the reliability of the work plan.,In case of failed assignments, root cause analysis is done in order to prevent it from happening again (Ballard 2000*b*).	A weekly planning meeting is held and a Planned Percent Complete (PPC) is measured This is to identify the constraints for the activities that have not been completed and measures should be taken in order to not do the same mistake again.	Both Veidekke and Skanska measure their respective PPC and record their reasons for non completions during the weekly meeting on Friday.	Similar

Theoretical Background	India	Norway	Similar/Different Practice between countries
Daily Huddles: A daily huddle is implemented in the form of a meeting between different inter-dependent groups and discussions are about the commitments each groups have completed and the commitments for which they need help from the other groups.This meeting generally takes place between front line supervisors of design squads and construction crews. (Ballard & Tommelein 2016)	The daily stand up meeting is held in the site regarding the daily plans and the main points to be discussed are what are the activities planned for the day and what are the things (like manpower and material information) that are needed to complete the activities for the day.	Skanska employs the daily job briefing where all the crews for the day go through their list of assignments. Veidekke does not use the daily stand up meetings.	Similar with Skanska
Visual Management: A Visual control system is used in depicting the exact status of the system for all the teams involved in the project in order to develop an understanding between them from which actions can be taken if necessary Ballard & Tommelein (2016).	Lookahead plans and weekly work plans are visually represented in the "BIG ROOM".	Skanska use this practice in their system only when there are lot of constraints to handle and Veidekke uses it for the 5-9 week lookahead plan and the weekly work plan.	Different

Theoretical Background	India	Norway	Similar/Different Practice between countries
Constraint analysis . Constraint analysis is primarily used to identify and remove constraints such that the uncertainty surrounding before the execution of the activity is released (Ballard 2000*b*). Workable Backlog: The assignments in a workable backlog might not release work, but these assignments are to be only used in order to utilize the available resources in case if it's idle and to maintain the continuity of assignments(Ballard & Howell 1998).	Constraint analysis and Workable backlog are performed as a part of lookahead planning. In case of any constraints they are visually represented by stickies in the "BIG ROOM"	Veidekke uses the constraint analysis during their PPD meeting and Skanska uses MS Project with a YES/NO column for constraint analysis, but the workable backlog is not used to a great extent by both the contractors.	Different

4.1.4 LPS Implementation Matrix

With the available case studies, interviews, comparison between the LPS theories with the practices Indian and Norwegian LPS practices, an attempt has been made to summarize the implementation grade of the LPS components in the investigated cases from Norway and India. The colors presented in Figure represent the degree of implementation and these scores were given by the author based on findings from the interviews and case studies and these scores are subjective in nature. Green denotes that the practical implementation is similar to LPS theory, yellow to some degree or

acceptable substitute practices and red denotes not corresponding at all. An important learning from the matrix is that the Norwegian projects, although having LPS incorporated in their systems, only use selected components on many projects. The Indian projects on the other hand, use almost all LPS components as described in theory, irrespective of a positive or negative outcome. The lean experts of Veidekke and Skanska experienced project success despite poor LPS implementation, as well as project failure despite successful LPS implementation. Therefore, it is difficult to directly correlate LPS implementation with project success based on LPS metrics (PPC). The matrix also, albeit based on a small number of cases, helped to identify various components from the literature that are currently being used in the Indian and Norwegian projects. The LPS component "First run studies" has been mentioned in the Literature but is not used in the Indian and Norwegian projects, not even to the slightest extent.

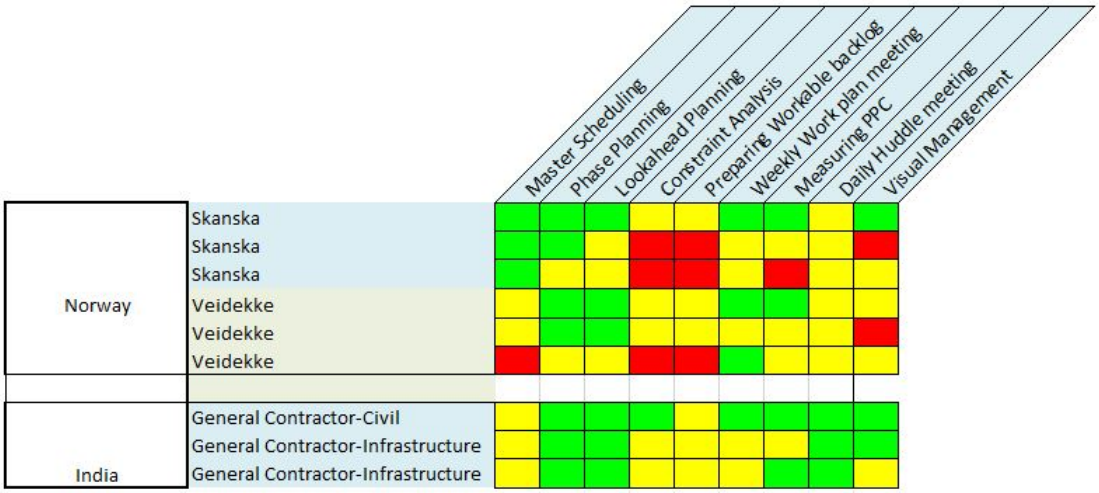

Figure 4.1: LPS Matrix

4.2 Experiences gained through LPS in India and Norway

This section is divided into two, where one part focuses on the challenges faced by the Indian and Norwegian lean consultants while implementing LPS in different projects and the other part focuses on the PPC measurements from the three different case studies in India. However, there was a limitation in this thesis that was mentioned in Chapter 1, where even though both the countries measured PPC every week in the LPS implemented projects, the Indian projects had a complete backup of all the PPC measurements, whereas the Norwegian contractors do measure PPC every week but do not have a backup in their system for the PPC measurements made. Hence the PPC measurements from the Norwegian projects could not be presented.

4.2.1 India

From the set of interviews and the case studies it was found that, there were quite a lot of experiences gained through implementing the last planner system in the case project. They were positive effects regarding the metrics and the work culture of the people, but there were some hardships during the initial stages of the implementation. These challenges are presented specific to the different meetings and planning sessions that were held in the site.

1. Phase Scheduling and Lookahead planning meeting: One of the main problems during the phase scheduling meetings was the lack of planning experience of the contractors and the planning engineers employed by them. Culturally people think of what's happening tomorrow and making them think on a long-term orientation is a cultural change that takes time i.e., people find it hard to straightaway plan for the whole phase or lookahead plan for 6-8 weeks. There are also Organizational challenges involved while long term planning, for instance if the lean consultant is hired contractors, they do not always get cooperation from the clients to remove constraints as part of the lookahead (make ready) process. This is partially because owners want the freedom to make changes till the end

and partly because they also lack awareness of the lean process.

2. Weekly work Meeting: In the initial stages of implementing this meeting, the site teams found it difficult to accept and follow it as a continuous process. Since this system was implemented in the middle of the project, it took a considerable amount of time for the participants to get used to this meeting. The participants were struggling to say exactly what they needed in terms of materials, resources or manpower. But with time and more practice, they got used to the process and they were more precise about their requirements. There are also socio-cultural challenges during this weekly planning meeting where the entry-level execution engineers find it hard to say "No" when there is a request from their managers (within the organization) or their Clients. They are either arm twisted or convinced to give the commitments that satisfy the expectations of senior management, irrespective of the actual situation. From a process perspective, senior management got the commitment from the execution engineer, but the dynamics is not collaborative as the execution engineer does not have the full freedom to say "No". The postulated reason behind this is the education system that is followed in India, where students, right from their childhood are taught to respect elders, teachers (hierarchy) and not to ask questions. Therefore, the lean consultants have the burden of getting them to "unlearn" this habit and create an environment people have the freedom and feel comfortable to say no.

3. Daily stand up meeting: From the investigated cases, the overall efficiency of the civil works has improved due to day-to-day close monitoring. Certain constraints that cannot be identified till the last moment might suddenly come during the daily stand up meetings. These constraints on site are usually in the form of drawings, payment (internal and external procurement) and labor mobilization. Here, labor constraints are very tricky as it relates to their payment on time and whether they receive workfront on time. An important issue was identified with the constraints here. In one of the interviews where the participant was involved in one of the cases, they found that subcontractors do know about the constraints but they failed to resolve it. In some instances they in-

form that constraints have not been resolved during the execution day of that particular activity.

4. Day to day monitoring:
   At the beginning, the supervisors were reluctant to attend the meeting especially for the reason because it was held at the end of the day, after a tiring long day for them. The PPC was measured right from day one of the LPS implementation, irrespective of whether everyone attended the meeting or not. However, there was a regular insistence from the third party lean consultants and the higher management week on conducting the meeting. After the second week of the LPS implementation, the supervisors realized that, they were able to execute the activities for which they gave the commitments. Teams were more positive after 2 weeks and started attending this meeting regularly. Everyone were glad to report about the activities that they managed to complete for that day and also report about the constraints, if anything.

Despite the challenges motioned that were specific to the meetings, one big obstacle to overcome was the monthly plans of contractors, as they were very much cost driven. Moving the contractors from a cost driven approach to a production driven approach gave a hard time for the lean consultants. Another big obstacle in the successful adoption of lean is the lack of reliable and regular payments from one stakeholder to another. Delayed payments to subcontractors leads to them not giving proper commitments, particularly to labor mobilization and procurement commitments. Even in scenarios where the contractors and subcontractors do get paid on time, they might deploy money received from one project to another where they are not getting regular payments etc. In short, the contractor's ability to manage their internal cash flows has a significant ability with the success of implementing LPS. The situation is not all bleak. Contractors and subcontractors that have benefited and seen positive outcomes do prefer to adopt it to other projects.
Implementing LPS for civil works have been quite successful in the Indian projects, but implementing in the MEP works is a challenge due to complexity of coordination across multiple vendors on information, payments, and work zones. Design happens close to construction, which means the contractors do not get good for construction

drawings when they start the execution, so Bill of Quantities (BOQ) is not frozen and procurement is not yet done fully. To cite an example, when civil works goes on, the information and materials for MEP are not available and so conducting a phase planning meeting for the finishing works in advance for MEP works before the completion of the civil works is a big challenge.

Apart from the case specific experiences, it was also found from the interviews that, there were further experiences gained by implementing the last planner system in other projects. Also, there was an important challenge identified in one of the cases with the client of that project. The client of that project had the routine of visiting the workplace regularly, not during the beginning stages but during the middle stages of the project where the execution was at its peak. The problem identified was that, during their visit to the workplace clients pass on orders to the site engineers to stop the execution of activities that even causes the slightest amount of disturbance to their visit. This project had some roadways to be built along with the buildings. So the client used to inform the site people one day before to stop digging the road that the client will pass through in the site and ask them to concentrate on a different work for that day. This badly disrupted the contractors ability to execute activities.

From one of the interviews with the Indian lean coach, it was revealed that the lean coaches have learned that, it was not just about getting success in terms of cost or time reduction of the project with the help of implementing LPS, but it was more about teaching the people about what LPS can add to a project when used in the right manner.

PPC measurements from Indian projects

Despite the mentioned challenges, the case studies were very useful in identifying some clear pockets of success in the form of an increasing PPC in all the cases studied. The PPC recordings from the three different cases from India have been graphically presented below.

Figure 4.2: PPC daily and weekly measurements-India (case 1)

- One of the projects experienced a reduction of cycle time by around 40%. The PPC on a daily basis increased from 30% to 49% and the PPC on a weekly basis increased from 46% to 81%. This data was measured for a period of 2 months.

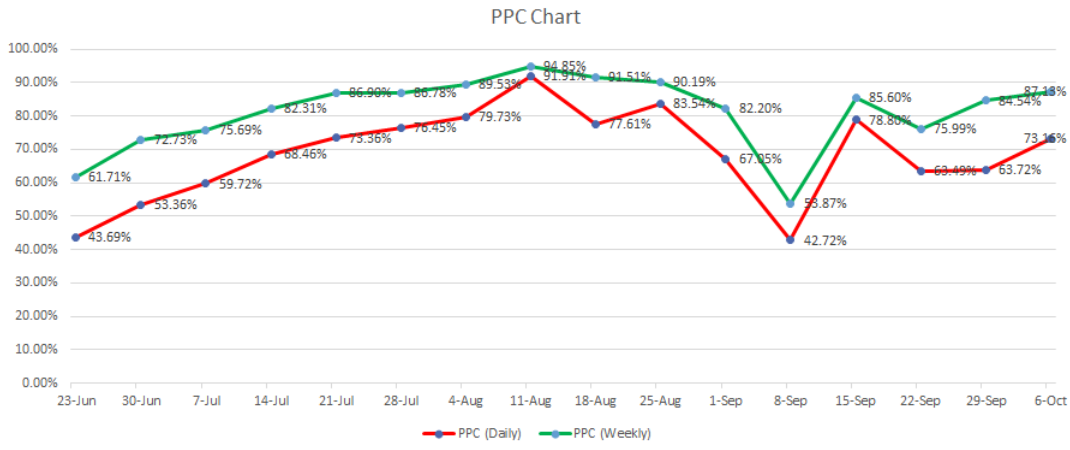

Figure 4.3: PPC daily and weekly measurements-India (case 2)

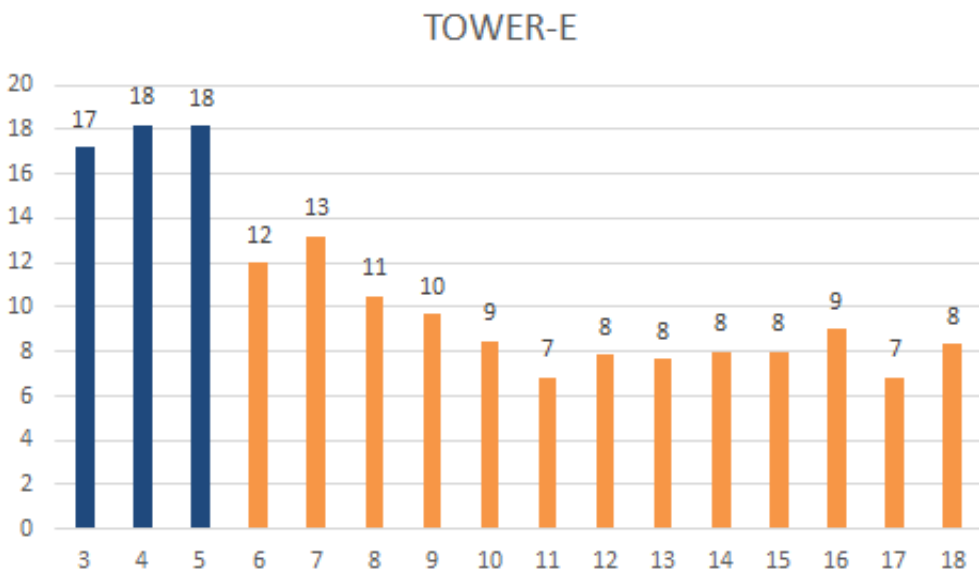

Figure 4.4: Change in cycle time- India (case 2)

- This project experienced an increase of daily PPC 43% to 73% from and weekly from PPC 61% to 87%. In the above picture, the dip in the PPC measurement was due to the flood in Chennai city, as a result of which people were unable to travel to construction site. Also, there was a decrease in the slab cycle time from 18 days to 8 days.

Sheet	WWP-01 - 07-11-16	WWP-02 - 14-11-16	WWP-03 - 21-11-16	WWP-04 - 28-11-16	WWP-05 - 05-12-16	WWP-06 - 12-12-16	WWP-07 - 19-12-17
Week	07-Nov	14-Nov	21-Nov	28-Nov	05-Dec	12-Dec	19-Dec
PPC (Daily)	40.25%	33.67%	43.68%	39.25%	66.54%	78.12%	91.00%
PPC (Weekly)	36.47%	26.23%	36.85%	32.10%	56.24%	64.25%	82.34%

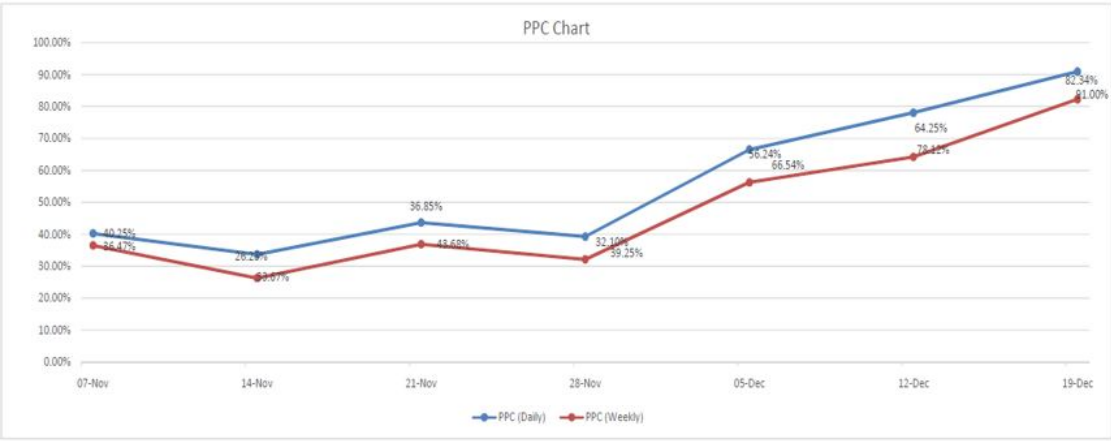

Figure 4.5: PPC daily and weekly measurements-India (case 2)

- In the third case study also, the contractor experienced a 45% reduction in completion of coping beams in civil works. PPC on daily basis increased from 40% to 91% and PPC on weekly basis increased from 36% to 82%. The increase in PPC was due to the increased awareness of non-completion by introducing a rigorous application of Value stream mapping of reasons for those non-completions. A more significant intangible benefit was the recognition from the Client who noted that the contractor's ability to make and keep commitments had significantly improved in the six months after the adoption of LPS.

4.2.2 Norway

From the interviews with the Norwegian practitioners, it was identified that there lies a challenge in managing people on different hierarchical levels looking at different time frames. For example, a manager for a labour group in Norway, when he is into LPS will be trained to plan ahead for one week and when he is promoted to a foreman he will be forced to plan for a longer timeframe i.e. 2-4 weeks. In this case, the foreman still disturbs the freedom of the manager who plans for the week, hence disrupting

the planning ability of the manager. This particular challenge was identified in 4 out of 6 cases in Norway. The challenge here lies with the people, as they need to be worked out of their comfort zone to a new system, which they have not been used to. LPS is out of many project participants' (especially the subcontractors) comfort zones compared to traditional planning methodologies. Many are used to having schedules created just for their trade and working in silos, without the rigorous coordination between trades and phases as LPS often promotes. Hence different trades in Norway when working together, find it hard to work as teams and coordinate with each other. Veidekke's lean coach expressed that subcontractors look for someone who can help in coordination between different teams.
In Norway, workers are good in planning for a particular week and when it comes to long term planning, there were no issues found with the contractor's planning engineers, but the issue was with subcontractors as long term thinking was hard for them. The payments plays a big role in Norway too. Unlike in India money plays a quite different role in Norway where contractors are not quite cost driven. For instance in Norway it was identified from one of the cases in Veidekke that, when the workers were paid well, they start thinking about executing the same activities in different ways. They were actually able to find some different practices and an example was given by the lean coaches where the labours found a very easy of sticking tiles on the floor which saved them a lot of time from the normal practice.

Clients in Norway normally do not care a lot about the Collaborative planning in site, but for the ones who are interested they get the PPC measurements every week, so they get to know how well it is working and they also receive the meeting minutes for every meeting. Apart from these challenges, there was instances found in the cases studies where subcontractors who managed to learn the practice in site, who have used it in the right way have given a positive feedback to the lean coaches and it was a special mention by subcontractors that that they would like to use LPS in their future projects.

These are some of the common challenges identified from Veidekke and Skanska. Looking more specific into both the contractors, they don't have too many other challenges apart from the ones mentioned above. However, both Skanska and Veidekke

do not just use the Last planner system in their projects. Veidekke has a mandatory system of LPS integrated with Takt time, whereas Skanska has a mandatory system of LPS integrated with LBMS. So, their experiences with integrating different lean tools are present below. Also, both the contractor's experiences of using LPS during the design stage have also been presented below.

Veidekke

Veidekke has a record of trying takt time planning, but they have failed when they use it separately. Therefore, they tried takt time planning integrated with LPS where they ask workers about the time requirements to finish activities by asking them to create a takt time. Even though, everything is planned to takt time every week it is checked whether they can do this, as there are adjustments all the time. For example, the same activity that was done last week in 3 days could be optimized better for the next week. Veidekke has not succeeded in using LPS in design stage as they feel it is difficult managing the specialist people in design. Veidekke uses its LPS integrated with takt time planning as a feature in their portfolio to win projects from clients and show the clients that they get good results because of this process.

Skanska

Skanska have also tried using the takt time but they haven't been successful. However, Skanska uses LBMS as a part of LPS in their system. Since there is a lot of information passing around the people from different trades, they find it difficult to organize it. The main challenge in the Norwegian industry lies during the start of the process on who is going to do what kind of work and the centre point of coordinating these people. Skanska has a really good record in managing the people in design and it has worked well for them more than the execution stage. There was a special mention by Skanska's lean coach that Skanska had a better PPC when LPS was used in design more than the PPC of execution stage. However, for Skanksa, in some of their projects even when everything went on right in using LPS both in construction and design, there have been really bad end results for the projects. Therefore, it is hard

for the lean experts to say whether the project was successful or not, just with LPS results.

There have been various experiences, positive and negative from both the countries and also some contrasting experiences from different contractors in Norway. The main challenge faced by the Indian projects are the dominant figure of the higher authorities who are either expecting too much from their workers or disabling them to do their work because of internal problems in the organization. Since LPS is often implemented in the middle of Indian projects, there is often inadequate time and focus on training up-front to properly establish the necessary culture and mindset. Participants initially struggled with common LPS skills such as clearly expressing what they need from each other, formulating well-described tasks, properly matching workload with needed labor etc. However, with time an increased schedule reliability and overall efficiency of the execution team have been observed in the studied cases. In case of Norway, the main problem identified was the individuality of the people, as they are too much concerned about their individual achievements rather than working in teams. This created a situation where workers in the site needed a driving force from the lean coaches to act as their center point of coordination. Individuality also played its part in India, but people realized they were able to execute the activities fast while working as a a team. The information about contractors in India was not written with the motive to generalize that all the contractors in India are the same, but this finding solely came from the cases studied and to be clear again it is not a general perception about the contractors in the country. The lack of experience of Indian planning engineers also come into play while planning whereas Norway provide with a better foundation for their employees by giving them introduction courses about planning before the start of the project in order to avoid this issue.

Positives that can be taken from the implementation of LPS from both the countries are that involving the last man at the site in the Planning process has increased the reliability of the 'Plan', coordination between different departments in the site has increased after the implementation of Last Planner System etc. A positive experience that was observed from the Indian side, was the improvement in the productivity of the labours which helped reducing the cycle times for activities. But this happened

only when they were able to track the PPC measurements, which was in a positive trend and this gave the workers a self motivation that they had it increase the PPC from the previous measurements. From the Norwegian side, it was the same when the participants felt ownership to the schedule they were very motivated gave positive feedback to the lean coaches regarding that.

4.2.3 Hofstede Analysis

Before going into the potential improvements for both the countries, Hofstede's six cultural dimensions for India and Norway has been analyzed. The figure presented below is Hofstede's scores for India and Norway, for the six cultural dimensions. These scores were taken from the official website of Dr. Geert Hofstede and proper references has been provided for checking these scores. These scores can be obtained for any country around the world.

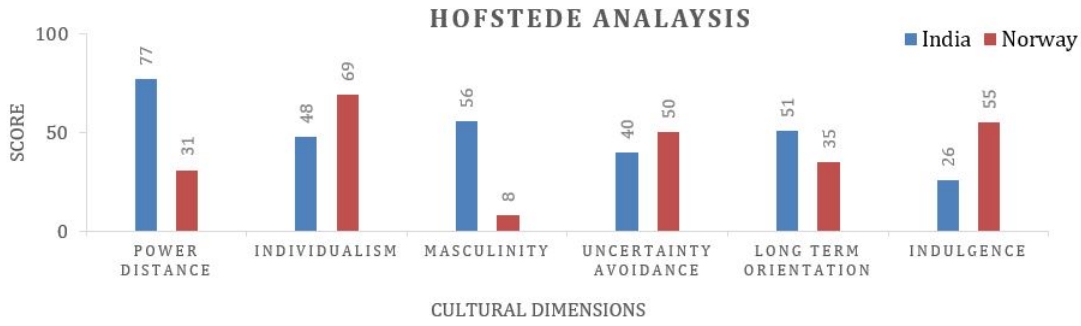

Figure 4.6: Hofstede Scores for India and Norway (*Hofstede Insights* n.d.)

With the available scores for both the countries, first a general comparison is made on what do these scores indicate based on the six cultural dimensions. The effect of these six cultural dimensions on LPS components has been discussed in the next part.

Table 4.2: India and Norway comparison based on Hofstede's score

Cultural dimension	India	Norway

Cultural dimension	India	Norway
Power Distance	With a score of 77, India has a top down hierarchy, indicating that people are dominated by their higher authorities and also dependent on them to be clearly directed on what is expected from them. Attitude towards managers are very formal and people find it difficult to offer a negative feedback up the ladder.	Norway, with a score 31, indicates that people are independent, the supervisors are easily accessible and management acts more as a facilitator. Power is decentralized, because of which the employees expect to be consulted. Attitude towards managers are informal and there is a direct communication between the higher management and the employees.

Cultural dimension	India	Norway
Individualism	India, with an intermediate score of 48, shows that collectivistic and Individualistic traits coexist. People around an individual like family or work group influence actions of that person. In this society, the employer/employee relationship play a key role in hiring and promotions. However, people are individually responsible for leading their lives and this small fraction individualist aspect interacts with the otherwise collectivist tendencies of the Indian society.	Norway with a score of 69 is considered an Individualist society, which means that individual, personal opinions are valued and expressed. Privacy is respected and there are clear lines between work and private life. Employees think more in terms of individual careers and the employer-employee relationship is based on a contract.

Cultural dimension	India	Norway
Masculinity	With a score of 56, India is considered a Masculine society. Here masculine society refers to the visual display of success and power by the people. Success is validated by material gains and achievements in the workplace. In countries that are more Masculine the focus is on success and achievements, validated by material gains.	Norway scores 8 and considered the second most Feminine society (after Sweden), which means that the culture has softer aspects like levelling with others and sympathy for underdogs. Focus is on well being and trying to be better than others is not rewarded. Managers here are supportive and decision are made through involvement.
Uncertainty avoidance	India has a low preference for avoiding uncertainty with a score of 40. This also means that there is a bit of room for imperfection i.e. people accept everything cannot go exactly as per the plan. People are comfortable with their established rolls and routines without questioning as people know how to "adjust".	Norway scores 50 and it is in the middle of accepting and rejecting uncertainties. Therefore, it is not possible to make a conclusion.

Cultural dimension	India	Norway
Long term orientation	With an intermediate score of 51 in this dimension, the society gives a slight advantage over being pragmatic (dealing with things sensibly and realistically) than normative (dealing things based on judgments). People feel more comfortable to go along their fated path rather than making an exact plan for the future.	Norwegian culture is more normative, with a relatively low score of 35. People focus on achieving quick results and do not intend to save much for the future.
Indulgence	India receives a low score of 26 in this dimension, considered a restrained society that does not emphasize on leisure time. People feel that their actions are restrained by social norms and feel that having pleasure with the things they like is somewhat wrong.	Norway has an intermediate, score of 55 in this dimension, making it more an indulging society. It is socially acceptable to show off their desires and it because of the way they are raised.

With the available Hofstede values and the general analysis of the six cultral dimensions of Norway and India the analysis of the cultural reasons behind the limited usage of LPS components has been presented below. This was done to get a general clarity on the country based on the scores and then jump into the cultural influences in LPS. There are six points listed below, each of which is a cultural dimension and it's definition. An example from the case studies/interviews from either Norway or In-

dia or both have been given for each cultural dimension in order to obtain a practical understanding on the effect of culture on LPS.

- Power Distance, “the extent to which a society accepts the fact that distribution of power in institutions and organizations is unequal”, India 77, Norway 31. An example would be socio-cultural challenges presented under the Indian side where the higher officials do not give the freedom to say "no" to the entry-level engineers. The Norwegian score indicates that Norwegians have a flat hierarchical structure, increasing their ability to say “no”, which seems like a very important premise for reliable promises. This might explain why Norwegian contractors have LPS incorporated into their systems of standard planning practices.

- Individualism, “the degree to which people in a country prefer to act as individuals rather than being a member of a group”, India 48, Norway 69. This factor relates to how the two countries see it natural to act as a single person or as a team. One way of interpreting this is that it should be more natural in India to appreciate LPS as a way of working as teams. An example would be the increase in the PPC shown in the two Indian case studies, as it increased when people started to work more as a team, not just achieving individual goals. From the Norwegian experiences it can be seen that that because of the individuality factor people needed a center point of coordination.

- Masculinity, “the extent to which the dominant values in a society are related to their assertiveness, acquisition of money and things”, India 56, Norway 8. This factor could be related to how decisions are made. Indians have assertive decision-making power within a few individuals of a group, while Norwegians might rather listen to all opinions before making collective decisions. This may cause that the pull-planning sessions in Norway are better to coordinate trades involved than those in India. An example could be from the interview with the Indian Lean consultant, where clients who visit the site for checking the progress would give orders to stop the activities that would disturb them during their visit.

- Uncertainty avoidance, "the extent to which a society tolerates ambiguous situations and tries to avoid these situations by establishing more formal rules and believing in absolute truths", India 40, Norway 50. This factor however could be related to how important it is for the teams to make work ready in a timely manner rather than accepting that not everything is in place before execution of work and making-do. An example would be organizational challenges, where the owners hesitate to take responsibility on the work of Lean experts. This is because owners were uncertain whether LPS would be a success or not if implemented, as it is new to the India. Another example could be the constraint analysis in India, where people tend to leave it easily without resolving the constraints till the last moment and informing about the constraint all of a sudden during the day of execution. Norway on the other even with medium score did not have problems related to this cultural dimension.

- Long-term orientation, "the ability of a society to connect the past with the current and future challenges", India 51, Norway 35. This indicates a better pre-condition for lookahead-planning in India than Norway. On the other hand, it might also indicate that India is more culturally prone to plan construction projects too much in detail too early, rather than following the LPS principle of planning to the right level of detail to the right time and accepting that things don't go as planned, but rather be able to change accordingly in an agile way.

- Indulgence, "the extent to which a society allows relatively free gratification of basic human desires related to enjoying life and having fun", India 26, Norway 55. This factor could be related to the social processes of LPS. Norwegians might be more comfortable with the informal tone and inter-personal communication often related to several components of LPS. An example could be the team bonding sessions conducted by Skanska for their workers, whereas India on the other hand had no such initiatives.

4.3 Potential improvements with LPS in the future

With the identified cultural enablers/roadblocks from both the countries, the potential improvements that could be made in India and Norway in order to improve the LPS process that could involve change in cultural ethos include:

4.3.1 India

- The execution engineer, in India, or the person responsible for the activity should be given the freedom to say "No", so that he can make reliable commitments. Owners should not involve in disrupting the planning ability of the contractors in the Indian side; they should be less "masculine" about it in the interest of the project.

- Clients and management (especially in cultures such as India) should try to be less "masculine" and empower entry-level field engineers to have opinions. Subcontractors and foremen can be gradually empowered to increase their planning capabilities and responsibilities. Especially if just asked to do short-term daily planning, one could increase responsibility to do lookahead planning and have more impact on identifying and handling constraints.

- Contractors, especially in India should improve their system by self-realization by making LPS as a mandatory in their system like in Norway and employ planning engineers who do not lack planning skills. Planning engineers should also be given training to LPS concepts beforehand.

- Indian counterparts could try LPS at two levels (learning from Norway): a short-term one that only involves coordination among contractors and a medium-term one that involves owners and contractors coordinating design and procurement since it was hard for the Indian contractors to plan ahead for MEP activities without design and drawings.

4.3.2 Norway

- Use a Bottom up approach for LPS on the Norwegian side, where the subcontractors and foreman can be taught to plan for the next day in the beginning and a step by step increase to asking them to do the lookahead plan for 6-8 weeks.
- For the Norwegian counterparts to try other aspects of LPS and see if that leads to improved reliability and efficiency of project delivery. Particularly, the constraint analysis and preparing the workable backlog could be tried by Skanska and the daily stand up meetings could be tried by Veidekke.
- The foreman who has to lookahead plan for 5-9 weeks and 2-4 weeks should ensure that their actions do not disrupt the 1-2 week plan of the sub-contractor.

Chapter 5

Conclusion

As the process of last planner system is still in its infancy in the Indian construction sector, it is still struggling to find a spot for itself (Ramakrishnan Ravi, 2017). While in the Norwegian sector contractors are well aware of the topic and have begun using it as a mandatory part of their project management system. This study provides results that help to fill the identified gaps in the body of knowledge, which is the role of culture in LPS and changes that can be made in LPS process with respect to the cultural aspects. This study focuses only on India and Norway and the results here relate to the culture of both the countries and changes that can be made in the LPS process in both the countries. The three research questions are answered with the help of literature reviews, case studies, interviews and relevant document studies.

5.1 LPS implementation in India and Norway

Looking at implementation experiences of the practitioners from the Indian and Norwegian industry, the need for cultural change to adjust to a new process such as LPS might take more time than anticipated by lean advocates. In terms of implementation, the findings from the interviews and case studies revealed certain similarities and dissimilarities between the countries in the methods of implementing LPS and also the

meeting structure's followed by them. India opt a simple form of implementation following the literature's, while Norway have embedded LPS into their system and have made some changes from the literature for their convenience. These changes have been based on both their comfort to work and their work culture.

5.1.1 India

- A phase schedule based on the contractual milestones is prepared, which is then broken down into a rolling 6-week lookahead schedule, weekly plans and daily plans as part of the weekly planning process.

- A weekly work planning meeting is held in order to plan the work that has to be executed in the upcoming week and to discuss top delay reasons of the PPC and potential improvements. A weekly planning meeting is held and the PPC is measured. This is to identify the constraints for the activities that have not been completed and measures should be taken in order to not do the same mistake again.

- Daily Standup meetings of maximum 20 minutes are conducted to gather PPC and delay reasons, as well as discussing shared tools and equipment for the next day. There is a strong emphasis for crews not to focus just on completing their workload, but to generate adequate finished work for the trade behind them, to ensure adequate flow of work at a reliable pace. Day-to-day Monitoring is done at the end of the day and PPC is measured for the activities of that particular day. Also, the coordination regarding the activities for the next day are also discussed.

All the meetings mentioned above takes place in the presence of various stakeholders in the project like execution team, contractor side staff, subcontractors, client side staff, PMC of that project and the third party lean consultant.

5.1.2 Norway

While the thesis is written to compare LPS in India and Norway, surprisingly the Norwegian part revealed certain dissimilarities between themselves in their working system. This does not result in any conclusion but an out of the box finding from the Norwegian case studies and interviews.

Norwegian contractors Skanska and Veidekke have the same planning procedure as in India but with a different meting structure.

Veidekke has four weekly progress meeting.

- The first one focusses on workforce and subcontractors plan their weekly work plan.
- They have another meeting where the foremen and subcontractors make their 2-4 week lookahead plan.
- In the third meeting, the site manager meets the project manager to discuss the 5-9 week lookahead schedule.
- In the fourth meeting, all subcontractors meet the foremen to discuss the work done that week by measuring the PPC and prepare work for the next week.

Skanska usually have three progress meetings per week for production work.

- One meeting involving participants from all the trades and one is for the foremen to coordinate.
- A daily job briefing, where each crew goes over their upcoming daily tasks, coordinates against other trades, material deliveries etc.
- A PPD (production-procurement-design) coordination meeting for the in-house managers which is done instead of Lookahead planning.

5.2 Experiences gained through LPS in India and Norway

Regarding the experiences, an important conclusion can drawn from the case studies. The last planner system was implemented half way through the projects in India and it was uncomfortable for the site teams to switch to a completely new process. So, it took quite some time to get tangible results. But, the lean consultants were backed up not only by the higher management, also by the site supervisors till the last foreman. Hence, they were able to produce results despite the delay in bringing LPS into the project. There have also been some contrasting experiences from the both the countries, where Indian Lean consultants have had the social and organizational challenges in the form of not giving freedom to say "No", the cash flow issues between the owners and contractors etc. On the other hand, Norway has issues with coordinating people, as they are individualistic in nature. A similar issue found between the countries was shifting the mind-set of the people to think from a short-term orientation to a long-term orientation.

Furthermore, Hofstede's six cultural dimensions have been helpful in explaining the experiences related to different LPS components. For instance, lookahead planning should correlate with the ability to think long-term, constraint analysis should correlate with the ability to accept uncertainty, masculinity might lead to Indian project teams having a few strong individuals making decisions on behalf of the team, while a Norwegian team depends on group decisions.

5.2.1 India

The experiences are arranged in a chronological order based on the scheduling and meetings on the site. Also, the experiences are presented with its relevant cultural enabler/roadblock that was found from the Hofstede analysis.

- Phase Scheduling and Lookahead planning: The main challenge was to make the people think ahead for which hofstede analysis was helpful in identyfing this problem based om the cultural dimension of Long term orientation.

- Weekly work Meeting
  Here the cultural dimension "Power distance" was helpful in identifying the dominance of the Indian higher managements where they don't give the freedom to say "No" to the workers as it was difficult for them to make a reliable promise.

- Daily stand up meeting: Even though people had different meetings to identify the constraints, there were certain instances where people inform about the constraint on the day of execution. This issue was a cultural one and it was based on the cultural dimension "uncertainty avoidance", since people were not too much concerned about eliminating constraints beforehand.

Despite the mentioned challenges, the interviews identified some clear pockets of success in implementing LPS as the PPC of the all the cases studied have been increased significantly and also the cycle time of certain activities have been reduced to a great extent. Apart from this, there were also positive changes with the subcontractors, contractors and clients who were involved in all the cases as they were very much into Lean after their first attempt. They found it really hard to accept it at start, but at the end of the project participants exactly realized what the lean coaches were trying to do. Indian Lean coaches received positive feed-backs from all the stakeholders involved.

5.2.2 Norway

Lean coaches in Norway had a hard time in managing the subcontractors as ehy are more used to working in a traditional style, working only to complete their tasks. It was also hard for them to manage people from different hierarchical levels and experiences have shown that people higher in the chain tend to disrupt the planning ability of people lower in the chain. Hofstede's cultural dimension Long term orientation helped in identifying the problem of thinking in a long term, as the participants found it hard to think for the future. Another cultural dimension "individuality" has been helpful in identifying the individualistic nature of the Norwegians. Lean coaches act as the centre point of coordination for the people in site who are more concerned only

about their work.

Experiences regarding the behaviour of people were the same for both the organizations. However, for the experiences regarding the usage of LPS integrated tools Veidekke and Skanska were found to have contrasting experiences. Veidekke has been successful with takt time integrated with LPS, whereas Skanksa have failed. On the other hand Skanska have been successful in LBMS integrated with LPS, whereas Veidekke have failed. Apart from this, the use of LPS in design stage also had contrasting experience where Skanska have been very much successful and Veidekke have failed as they feel it is difficult managing the specialist people in design.

5.3 Potential improvements with LPS in the future

For both the countries, the cultural reasons that plays a big role in implementing different LPS components have identified with the help of Hofstede analysis. With the help of case studies, interviews, Hofstede's cultural dimensions, cultural problems were identified that interrupted in using LPS to its full potential. Listed below are the future improvements for both the countries considering the aspect of culture.

5.3.1 India

- The execution engineer, in India, or the person responsible for the activity should be given the freedom to say "No", so that he can make reliable commitments. Owners should not involve in disrupting the planning ability of the contractors in the Indian side; they should be less "masculine" about it in the interest of the project.

- Clients and management (especially in cultures such as India) should try to be less "masculine" and empower entry-level field engineers to have opinions. Subcontractors and foremen can be gradually empowered to increase their planning capabilities and responsibilities. Especially if just asked to do short-term

daily planning, one could increase responsibility to do lookahead planning and have more impact on identifying and handling constraints.

- Contractors, especially in India should improve their system by self-realization by making LPS as a mandatory in their system like in Norway and employ planning engineers who do not lack planning skills. Planning engineers should also be given training to LPS concepts beforehand.
- Indian counterparts could try LPS at two levels (learning from Norway): a short-term one that only involves coordination among contractors and a medium-term one that involves owners and contractors coordinating design and procurement since it was hard for the Indian contractors to plan ahead for MEP activities without design and drawings.

5.3.2 Norway

- Use a Bottom up approach for LPS on the Norwegian side, where the subcontractors and foreman can be taught to plan for the next day in the beginning and a step by step increase to asking them to do the lookahead plan for 6-8 weeks.
- For the Norwegian counterparts to try other aspects of LPS and see if that leads to improved reliability and efficiency of project delivery. Particularly, the constraint analysis and preparing the workable backlog could be tried by Skanska and the daily stand up meetings could be tried by Veidekke.
- Norway: The foreman who has to lookahead plan for 5-9 weeks and 2-4 weeks should ensure that their actions do not disrupt the 1-2 week plan of the subcontractor.

Apart from the research questions, there was another question raised at the start which stated " whether the change should be the way of practicing LPS or whether the change should be from the people". The answer to this question can be given based on the experiences of lean coaches from both the countries. In India it was identified that people tend to work well in teams improving productivity and increasing the PPC. But the problem arises with the contractors where they fail to deploy LPS in their system,

which calls for a third party lean consultant. This also resulted in implementing LPS half way through the projects. People were suddenly shifted to a new way of working which was hard for them. On the other side for the lean consultants coming into the project in the middle stages, they found it difficult on how to explain LPS to people. So they lacked a proper set of training and introduction for the participants to understand more about the process. Norway takes a totally different stand in this issue. The contractor's LPS ideologies are really well laid out which reflects in their system with a very well structured meeting structure and planning methods. They do really well in introducing LPS to the participants making them well prepared for the system even before they begin the project. But the issue in Norway is with the subcontractors and foreman, as they have the issue of individuality where they lack a bit of team working. So even with a great system Norway finds it hard to succeed to a great extent, because of the working nature of the people. An important aspect of construction management is "Connectivity" because with a better connectivity between people and process there could be a better flow of resources and information (Howell & Koskela 2000). For LPS implementation to be successful it is very important that people have a good rapport with the system they are working in.
All in all, both sides have something to learn from each other's successes (or lack thereof). And both sides have some room to improve their cultural baggage to improve the adoption of the principles of LPS and achieve better success in project delivery through the use of LPS. In general, the Lean Construction community should have even more discussions about the cultural pre-conditions of the countries, companies and project organizations where Lean Construction practices are implemented. There is a need for improved insight of what factors that enable successful adoption.

To conclude, the author thinks that LPS implementation relies on several aspects and both countries discussed in this thesis has strengths and weaknesses in doing so effectively. The Norwegian culture has a benefit in terms of the flat structure and inclusive group dynamics required for LPS, but perhaps could struggle with too much individualism and keeping the production system organized and loyal to the production system. India seems to have a strong culture to the systematic approach of implementing LPS (which in reality is a system of several components) and could be more loyal to keeping such a system updated and followed as recommended, but might struggle

more to get the inclusive group culture of LPS where entry-level employees dare to speak up against poor planning commitments.

Based on the results of this study, a conclusion of the implementation, experiences and future improvements that can be made in India and Norway have been obtained. With more research into the last planner system, it is pretty sure that the research gap can be addressed to the full extent.

Chapter 6

Further Work

This master thesis has analyzed the cultural background of India and Norway with the help of Hofstede's six cultural dimensions. With the help of this analysis certain recommendations were given in order to improve LPS process in consideration with the cultural aspects. In general, it is recommend that the Lean Construction community have even more discussions about the cultural pre-conditions of the countries, companies and project organizations where LPS is implemented, to gain greater insight of what factors that enable successful adoption.

However, there were certain limitations in the research methodology that was undertaken and improving certain aspects in the research methodology would be a useful work to undertake in the future. With better access to the projects in India several other cases regarding LPS in India can be studied which will help in gaining more insight into the implementation style and a variety of new experiences while implementing LPS in the Indian construction projects. Also, further more cases in a different locations in India would be really useful and India has a totally contrasting subcultures all over the country. Regarding the Norwegian side, even though cases were studied a future work could be studying the PPC measurements of the projects and comparing them with the Indian PPC measurements. This leads to a better comparison between the countries, as one gets to know how well both the countries have kept up their promises which can be seen from the PPC measurements.

Hofstede analysis on the other hand played a big role for identifying problems, but did not play a part in giving solutions for those cultural problems. However, there are several other cultural studies regarding different countries, but Hofstede analysis was selected because the six cultural dimensions that were mentioned in the analysis could be directly related to different components of LPS. Other cultural studies can be Meyers-Briggs personality framework, which is an "introspective self-report questionnaire with the purpose of indicating differing psychological preferences in how people perceive the world around them and make decisions" (Briggs-Myers & Myers 1995). A suggestion can be selecting lean coaches, construction managers and clients from both the countries, so that both sides of the arguments can be heard. Studying about individual personalities involved in projects rather than looking at the whole culture will be a better aspect for studying the culture of a country resulting in a better set of data for analysis, ultimately leading to a better set of recommendations.

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Appendix

Appendix A

Literature Search process

Methodology The first step for finding relevant literature on the subject of Lean construction and its component Last Planner system is to understand the subject. Thus, known literature, such as The Last Planner (Ballard 1994), What is Lean Construction (Howell 1999), was read. From these, the keywords that would be used in the search for literature were found. Also, by using backwards snowballing (Wee and Banister 2016), it was possible to find more relevant literature from known sources. An example of that is the LEARNINGS FROM APPLICATION OF LAST PLANNER IN A RESIDENTIAL PROJECT (Vaidyanathan, Mohanbabu, Sriram, Rahman & Arunkumar n.d.), that was found by backwards snowballing in the references of the "Application of lean principles to managing construction of an it commercial facility - An Indian experience". After that, the search was done based on the different combination of keywords on known databases such as Oria.no, Google Scholar, Scopus. For all the databases the same steps were followed and it was able to get consistent results. The procedure was the following:

1. Go to the database and search with the keywords.
2. Search functions and operators were used to get the precise results from the keywords.
3. Then screening was done by having a look at the titles and it makes it easy to

exclude the ones that were not relevant.

4. After that, the abstract of the articles which had relevant titles were read and a final screening was done.

Here the subject deals with 2 countries, so there are more than one combination of keywords. This keyword was kept constant in all the databases and the literature was obtained. For example, the keywords Last planner system and India were used in different databases mentioned above and the search results were obtained. The above explained is for one keyword. But due to the large scope of the topic 4 different combination of keywords were used. They are:

- Lean Construction AND India
- Lean Construction AND Norway
- Last planner system AND India
- Last planner system AND Norway

One more combination was added and this was solely based on a particular author Mr. Glenn Ballard, who was the creator of the Last Planner system. So, the combination of Last Planner system and Glenn Ballard would be a good way to find the papers that he have been published by him till now related to Last Planner. To perform the evaluation of the literature, the content, the reliability and the relevance of each source was evaluated.

- To evaluate the content questions about the credibility of the author and the content of the paper were analyzed.
- For evaluating the quality of the sources, there was a check made on the publisher of the article.
- In order to evaluate the relevance of the sources, the relation of the paper to the chosen topic was analyzed.

Only the credentials of the primary author was checked in order to reduce the length of the evaluation. So, the literatures obtained from different databases are catego-

rized based on the differen combinations of keywords used. Also, in order to get a better idea of how to approach the literature report review, two reports from the previous years were studied. They were the reports of Stavros Adamou (M.Sc. Project Management, NTNU) and Brendan Young (M.Sc. Project Management, NTNU).

Oria.no

This is the online library database for NTNU and it allows the user to search the online databases of all Norwegian Academic Libraries, electronic and printed books, articles and journals. The search function allows the user to make a search based on the keywords or phrases in the title, abstract or the whole text, So the different combination of keywords gave lot of search results. Then some filtering was done and the most relevant articles are mentioned below.

Lean Construction AND Norway: Here, in this combination there were 6036 hits, but the search function "Sort by" was used and it was changed based on the relevance of the keyword. Then, after 2 pages no documents were relevant to the keyword. So the documents in the first two pages were screened based on the title and only one paper was relevant to the topic.

a. Andersen, B., Belay, A.M. and Seim, E.A., 2012. Lean Construction Practices and its Effects: A Case Study at St Olav's Integrated Hospital, Norway. Lean Construction Journal.
Other than the sequence mentioned above no other sequence had a relevant paper, so it is not mentioned here.

Scopus

Scopus is one of the most reliable database to search for references and it is also the biggest one which has peer-reviewed journals. Here again, the same five combinations of keyword sequences were used

- Lean Construction AND Norway: There were a total of 10 hits and only one

paper was relevant.
a. Skinnarland, S., 2012. Norwegian project managers and foremen's experiences of collaborative planning. In Proceedings of the 20th annual conference of the International Group for Lean Construction (pp. 1-10).

- Lean Construction AND India: There were a total of hits 8 and two papers were relevant.
  Vignesh, C. 2017, "A case study of implementing last planner system in Tiruchirappalli District of Tamil Nadu - India", International Journal of Civil Engineering and Technology, vol. 8, no. 4, pp. 1918-1927.
  Raghavan, N., Kalidindi, S., Mahalingam, A., Varghese, K. Ayesha, A. 2014, "Implementing lean concepts on indian construction sites: Organisational aspects and lessons learned", 22nd Annual Conference of the International Group for Lean Construction: Understanding and Improving Project Based Production, IGLC 2014, pp. 1181

- Last Planner system AND India: There were a total of 3 hits and only one paper was relevant.
  Vaidyanathan, K., Mohanbabu, S., Sriram, P., Rahman, S. Arunkumar, S. 2016, "Application of lean principles to managing construction of an it commercial facility - An Indian experience", IGLC 2016 - 24th Annual Conference of the International Group for Lean Construction, pp. 183
  The sequences Last planner system AND Norway and Last Planner and Glenn Ballard did not have any relevant results in, so it is not mentioned here.

Google Scholar

As the search for literature in the previous two databases did not produce as many references as expected, the next database used was Google Scholar. Here again, the same five combinations of keyword sequences were used.

- Last Planner System AND Norway: There were a total of 37,500 hits and same function that was used in Oria.no was used here. The references were sorted out by relevance and after 4 pages; there were no papers relevant to the topic.

Hence the papers in the first four pages were screened on the titles and abstracts and only one paper was relevant
Kalsaas, B.T., Skaar, J. and Thorstensen, R.T., 2009. Implementation of Last Planner in a medium-sized construction site. In Proceedings of the 17th Annual Conference of the International Group for Lean Construction, Taipei, Taiwan (pp. 15-30).

- Last Planner System AND Ballard There were a total of 22,200 hits and same function and the references were sorted out by relevance. They were screened on the titles and abstracts and only one paper was relevant
Ballard, H.G., 2000. The last planner system of production control(Doctoral dissertation, University of Birmingham).
Ballard, G. and Howell, G., 2003, July. An update on last planner. In Proc. 11th Ann. Conf. of the Int'l. Group for Lean Constr (pp. 22-24).
Seppänen, O., Ballard, G. and Pesonen, S., 2010. The combination of last planner system and location-based management system. Lean Construction Journal, 6(1), pp.43-54.

Literature list:

1. Ballard, H.G., 2000. The last planner system of production control (Doctoral dissertation, University of Birmingham).

2. Ballard, G. and Howell, G., 2003, July. An update on last planner. In Proc. 11th Ann. Conf. of the Int'l. Group for Lean Constr (pp. 22-24).

3. Raghavan, N., Kalidindi, S., Mahalingam, A., Varghese, K. Ayesha, A. 2014, "Implementing lean concepts on indian construction sites: Organisational aspects and lessons learned", 22nd Annual Conference of the International Group for Lean Construction: Understanding and Improving Project Based Production, IGLC 2014, pp. 1181

4. Vaidyanathan, K., Mohanbabu, S., Sriram, P., Rahman, S. Arunkumar, S. 2016, "Application of lean principles to managing construction of an it commercial facility - An Indian experience", IGLC 2016 - 24th Annual Conference of the

International Group for Lean Construction, pp. 183

5. Vignesh, C. 2017, "A case study of implementing last planner system in Tiruchirappalli District of Tamil Nadu - India", International Journal of Civil Engineering and Technology, vol. 8, no. 4, pp. 1918-1927.

6. Vaidyanathan, K., Reddy, P., Yamgar, S. and Dhekale, R., 2015, February. Learnings from Application Of Last Planner In A Residential Project. In First Annual Conference of Indian Lean Construction Conference (pp. 316-327).

7. Andersen, B., Belay, A.M. and Seim, E.A., 2012. Lean Construction Practices and its Effects: A Case Study at St Olav's Integrated Hospital, Norway. Lean Construction Journal.

8. Skinnarland, S., 2012. Norwegian project managers and foremen's experiences of collaborative planning. In Proceedings of the 20th annual conference of the International Group for Lean Construction (pp. 1-10).s

9. Kalsaas, B.T., Skaar, J. and Thorstensen, R.T., 2009. Implementation of Last Planner in a medium-sized construction site. In Proceedings of the 17th Annual Conference of the International Group for Lean Construction, Taipei, Taiwan (pp. 15-30).

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

Literature evaluation:
Reference 1: Ballard, H.G., 2000. The last planner system of production control (Doctoral dissertation, University of Birmingham).
Database found: Google Scholar
Author: Glenn Ballard
Publisher: University of Birmingham
Number of citations: 1111
Content Evaluation: This PHD thesis discusses about the last planner system as a control system, as it helps in managing the contracts, which is a concern for the project

management, by making the plans with more reality and giving quality assignments. Also, this thesis talks about the coordination of different parties involved in a project, which is the basic or the last planner system and this explanation is considered to be the state-of-art. These were done with a series of case studies from different project in different countries (Ballard, H.G., 2000).
Quality Evaluation: The doctoral thesis is submitted through a respectable university, University of Birmingham, and was supervised by David Seymour. The author, Mr. Glenn Ballard is the creator of the last planner system and this thesis is like a bible to those who want to do a literature review on last planner system. It talks about almost each and every aspect, that is getting really popular In most of the countries now. Hence the quality is considered to be the best. This thesis is also one of the most cited articles for the Last Planner system topic.
Relevance: The article is very relevant to the subject of the specialization project, in regard in understanding the procedures of the front-end governance of projects. Also, it gives examples improved implementation of the Last Planner system of production control to increase plan reliability above the 70% PPC level. For these reasons, the article is considered highly relevant for the literature research of the specialization project.

Reference 2: Ballard, G. and Howell, G., 2003, July. An update on last planner. In Proc. 11th Annual Conference of the International Group for Lean Construction (pp. 22-24).

Database found: Google Scholar

Author: Glen Ballard and Greg Howell

Publisher: 11th Annual Conference of the International Group for Lean Construction

Number of citations: 192

Content valuation: This paper is an update of “The Last Planner (1994)” by Glenn Ballard and the update is based on the improved style of implementing the last planner system. This involves betterment in the theory of last planner, structuring of the work, phase scheduling process etc. The method of team pull is introduced in this pa-

per, which describes about creating phase schedules for creating the work plans and specifying the handoffs between different specialists in the group (Ballard, G. and Howell, G., 2003).

Quality evaluation: This is one of the most cited articles on the Last Planner system since it forms the very basis of how to use it effectively in practice. This document was published in the 11th annual conference of the International group for Lean construction. Author is Mr. Glenn Ballard and Mr. Greg Howell who are the most experienced and most cited authors in Lean construction. So the quality is considered to be really high.

Relevance valuation: This paper is the 2nd most relevant literature needed for the topic, after the “The Last Planner (1994)”. It consists of the key elements of last planner system, and after this updated paper was published, the last planner system became more popular in the construction industries. This gives the basic theory that is need to understand how the last planner system works, which will be useful to understand the basics of Last planner, irrespective of the countries implemented.

Reference 3: Raghavan, N., Kalidindi, S., Mahalingam, A., Varghese, K. Ayesha, A. 2014, "Implementing lean concepts on indian construction sites: Organisational aspects and lessons learned", 22nd Annual Conference of the International Group for Lean Construction: Understanding and Improving Project Based Production, IGLC 2014, pp. 1181

Database found: Scopus

Author: Raghavan, N

Publisher: 22nd Annual Conference of the International Group for Lean Construction

Number of citations: 4

Content evaluation: The main topic discussed in the paper is that, Indian Institute of Technology(IIT) Madras which is an educational institution in India, has undergone training and implementation of Lean construction practices in the Indian AEC Industry through classroom and also webinar-based trainings. These were theoreti-

cal practices, but they also implemented Lean construction in nine different projects in India. Periodic reviews and monitoring the activities through site visits were also done. The core principle used in the sites was LPS and other lean tools like Value stream mapping and work sampling were also used. The results were analyzed based on the organizational and cultural aspect of the sites (Raghavan, N., Kalidindi, S., Mahalingam, A., Varghese, K. Ayesha, A. 2014).

Quality evaluation: The main author is Mr. N. Raghavan, INAE Distinguished Visiting Professor at Indian Institute of Technology (Madras), India. It is considered to be the best university in India and one of the best in the world. This article was published in the 22nd annual conference of International Group for Lean Construction (IGLC), 2014. This is a conference started in the year 1996 in Birmingham, UK and it happens once in a year. In this conference people from all over the world present papers on their experiences from using Lean construction. The quality of the papers published in this conference are really high, as not every paper that is sent is published in the conference. A lot of screening is done for the papers which are published. Also, it is written by the authors who have a Phd. in construction management and also they have been involved in developing Lean construction India for a long time, so the quality is considered to be really high.

Relevance evaluation: The article is very relevant for literature review, for the analysis of what kind of Lean principles are currently in practice in India and also how well is lean accepted in India. The paper deals with case studies from 9 different projects and it is very useful to conduct a case study in India with the help of this paper.

Reference 4: Vaidyanathan, K., Mohanbabu, S., Sriram, P., Rahman, S. Arunkumar, S. 2016, "Application of lean principles to managing construction of an it commercial facility - An Indian experience", IGLC 2016 - 24th Annual Conference of the International Group for Lean Construction, pp. 183

Database found: Scopus

Author: Kalyan Vaidyanathan,

Publisher: IGLC 2016 - 24th Annual Conference of the International Group for Lean

Construction

Number of citations: 0

Content evaluation: In this paper, the authors have managed to use the LPS and VSM and some other Lean tools like Location based management system (LBMS), in order to make an improvement in the execution of 200,000sqm commercial facility project. The main hardship in the project was, it had to be delivered in 24 months. With the Last Planner System™ (LPS), which was used in the civil phase of the project reduced the cycle time. In case of the MEP phase, the combination of LPS and LBMS was used. This project was the first one India to use LPS and LBMS combined, and it was effective to coordinate workfront in cooperation with the subcontractors. They have also discussed about the challenges faced in the implementation and ways of overcoming them (Vaidyanathan, K., Mohanbabu, S., Sriram, P., Rahman, S. Arunkumar, S. 2016).

Quality evaluation: This article was also published in the 24th annual conference of IGLC 2016. Also, it is written by the author Mr. Kalyan Vaidhyanadhan, who is one of the most respected authors in the field on Lean construction in India. Also he is the CEO of Nadhi Information technologies, which is the Chennai hub of the Institute for Lean Construction Excellence (ILCE) in India. Hence it is considered to be of a very good quality, even though it has not been cited.

Relevance evaluation: This article has a single case study but it involves a majority of Lean principles like LPS, VSM, LBMS, which forms the basis of the literature and it also discusses about the Indian mindset of implementing Lean construction practices. This would be really useful in analyzing on the challenges of bringing lean into India. This paper is not that much different from the previous one, except in the number of case studies, but the main reason was it helped a lot to get a better idea on how is Lean construction doing in India at present.

Reference 5: Vignesh, C. 2017, "A case study of implementing last planner system in Tiruchirappalli District of Tamil Nadu - India", International Journal of Civil Engineering and Technology, vol. 8, no. 4, pp. 1918-1927.

Database found: Scopus

Author: Vignesh, C

Publisher: International Journal of Civil Engineering and Technology

Number of citations: 1

Content evaluation: This paper describes about the implementation of the Last Planner system in an ongoing construction project and it was to analyze how LPS improves the performance and productivity. The research was carried out in a Bishop Heber coll where only one contractor was involved in the construction of multipurpose buildings. To identify the current practices and exposure that LPS has in India, a comparison-based survey was conducted with different professionals from the construction field. From the results, LPS contributed to a significant improvement and increase in average Percentage Plan Completed (PPC). It also discusses the LPS's benefits and barriers (Vignesh, C. 2017)

Quality evaluation: The author is a Masters student in Construction Management at Manipal University, India. This university is in the top 5 rankings in India. This article was a published in the International Journal of Civil Engineering and technology (IJCET), which has an h index of 8 since 2012 , and the number of citations from this journal are 1248 in the period of 2010 to 2015 (http://www.iaeme.com/CitationReports.asp). Hence the quality of the article is considered to be good.

Relevance evaluation: The previous two articles deals more with 3 major lean principles (LPS, VSM and LBMS) and it was referred to get a whole idea of different lean tools that are being in practice. Since the literature review is mainly based on the study of last planner system, this paper is highly relevant because it discusses only about the implementation of LPS in a construction project in India. This makes the paper very much relevant for the literature review.

Reference 6: Vaidyanathan, K., Reddy, P., Yamgar, S. and Dhekale, R., 2015, February. Learnings from Application Of Last Planner In A Residential Project. In First Annual Conference of Indian Lean Construction Conference (pp. 316-327).

Database found: Google Scholar

Author: Kalyan Vaidyanathan

Publisher: First Annual Conference of Indian Lean Construction Conference

Number of citations: 1

Content evaluation: This paper discusses the implementation of Last Planner system in a turnkey project in Gujarat, India which consists of the construction of four buildings and on average each building has six floors. This project was expected to be delivered in 10 months. The paper describes the benefits gained by implementing the Last Planner System™(LPS) by which the delay in civil works was reduced by about 40 days. Also, the item rate billing model of the subcontractor in that project was discussed and what changes they had to make in the LPS process is also discussed. The change in the attitude of the stakeholder's side from being commanding and controlling to using more of the participative planning is discussed (Vaidyanathan, K., Reddy, P., Yamgar, S. and Dhekale, R., 2015)

Quality evaluation: The author is Mr. Kalyan Vaidyanathan and the information about his credibility were given above. This article was also published in the first annual Indian Lean conference, which takes place in India involving only the practitioners of Lean construction in India. The conference comprises of academic paper presentations and industrial case-studies on Lean principles in the Indian AEC Industry. The conference is organized in cooperation with IGLC (International Group for Lean Construction) and LCI (Lean Construction Institute) conferences, which are of great importance from the international perspective. These conferences have established the concepts of Lean construction in all around the world.. So, it considered to be of high quality.

Relevance evaluation: Same as the previous article, this article also discusses mainly about the Last Planner system in a construction project, and it is implemented in a turnkey project. As mentioned previously to get a broader idea on LPS in India, one article is not enough. Hence, the same kind of article, but with different authors and different kind of project is very useful to get a better idea of what is exactly happening

with LPS in India..

Reference 7: Andersen, B., Belay, A.M. and Seim, E.A., 2012. Lean Construction Practices and its Effects: A Case Study at St Olav's Integrated Hospital, Norway. Lean Construction Journal.

Database found: Oria.no

Author: Bjørn Andersen

Publisher: Lean Construction Journal

Number of citations: 2

Content evaluation: This paper investigates about the implementation of different lean tools at St. Olav's integrated hospital in Trondheim. It was started in phase 2 of the project and several changes in the attributes of the project were found out, when compared with a traditional style of approach. Also, there is a detailed and a structured review about the Lean Construction practices and effects in the project (Andersen, B., Belay, A.M. and Seim, E.A., 2012)

Quality evaluation: The main author of this article is Mr. Bjørn Andersen, who is a professor at NTNU and has published quite a lot of papers in the field of project management. This article was also published in the Lean construction journal, which is published by the Lean Construction Institute (LCI) and it was started in the year 2003. It has an h index of 3 according to the Scimago Journal Country Rank (www.scimagojr.com). Even, though the journal is not a top one, the author is very credible, and hence this article is a quality one.

Relevance evaluation: One side of the literature review consists of the LC practices In India and on the other side it is Norway. So this paper is a really good one to start with, to get an idea about the approach of the Norwegian people in the field of Lean construction. Hence, for the latter part of the Literature review this paper is very relevant.

Reference 8: Skinnarland, S., 2012. Norwegian project managers and foremen's experiences of collaborative planning. In Proceedings of the 20th annual conference of

the International Group for Lean Construction (pp. 1-10).s

Database found: Scopus

Author: Skinnarland, S

Publisher: 20th annual conference of the International Group for Lean Construction

Number of citations: 3

Content evaluation: This paper reports about a Norwegian company which has implemented Last Planner in one of it's projects. The company has implemented LPS for the first time in 2008 in two pilot projects and then it went on a regular basis. So, it mainly discusses about the experiences gained by the project managers and foremen by using LPS in that project. The research was through group interviews with 34 informants who were asked about the elements, outcomes, challenges of using LPS (Skinnarland, S., 2012).

Quality evaluation: The author is Mr. Sol Skinnarland, who is a researcher in the Institute of Labour and Social research which is in Oslo, Norway. Also, this article was published in the 20th annual conference of IGLC. As mentioned before the quality of papers that are published in this conference are really high.

Relevance evaluation: This paper is very aligned to the literature review, since it discusses mainly about the collaborative planning for a particular company in Norway. The main relevance is, the paper focuses mainly on LPS and not any other lean tools. Since, the latter part of the literature is about LPS in Norway, it helps understand in detail about the implementation of Last planner system in Norway.

Reference 9: Kalsaas, B.T., Skaar, J. and Thorstensen, R.T., 2009. Implementation of Last Planner in a medium-sized construction site. In Proceedings of the 17th Annual Conference of the International Group for Lean Construction, Taipei, Taiwan (pp. 15-30).

Database found: Google Scholar
Author: Kalsaas, B.T

Publisher: 17th Annual Conference of the International Group for Lean Construction

Number of citations: 18

Content evaluation: The paper addresses on the implementation of the Last Planner system by Skanska, in a 6800 sq.m construction project which comprises of a kindergarten, junior high school and a sports and cultural centre. The main challenge that was faced in the implementation was the coordination between different actors involved in the LPS (the architect, the general contractor and the owner), as it was dysfunctional in order. Proposals for further improvements in the Last Planner system was discussed (Kalsaas, B.T., Skaar, J. and Thorstensen, R.T., 2009).

Quality evaluation: The main author is Mr. Bo Terje Kalsaas who is an associate professor in University of Agder, Norway. With 18 citations, this article was published in the 17thannual conference of IGLC. As mentioned before the quality of papers that are published in this conference are really high.

Relevance evaluation: It is also relevant as the previous article, implementing LPS in a construction project, and study on how the Norwegian approach is for the LPS. As the previous article had just one case from Norway, it was not enough to get the whole point of view. That is the main reason this paper was chosen to study.

Reference 10: Seppänen, O., Ballard, G. and Pesonen, S., 2010. The combination of last planner system and location-based management system. Lean Construction Journal, 6(1), pp.43-54.

Database found: Google Scholar

Author: Olli Seppänen

Publisher: Lean Construction Journal

Number of citations: 68

Content evaluation: The paper has specified about merging the Last Planner system and the Location based management system together as a process. Skanska Finland has implemented this process of LPS and LBMS together. Case studies were done

from three sources in United states, where three companies were interviewed in order to find out the factors which influenced the activity based scheduling systems. As a conclusion, the paper proposes to integrate LPS and LBMS in pre-bid master scheduling, pull phase scheduling, look-ahead scheduling, and weekly planning. But the drawback was these processes have not been tested in practice (Seppänen, O., Ballard, G. and Pesonen, S., 2010)

Quality evaluation: The main author is Mr. Olli Seppänen who is a Post. Doc researcher at Aalto University, Finland. Since, the co-author is Mr. Glenn Ballard, the quality of the article was considered to be high. This article was also published in the Lean construction Journal.

Relevance evaluation: This paper has a little relevance on the subject, because it neither talks about LPS in India nor Norway. Furthermore the relevance this paper has is that, it has suggested a method of combining LPS and LBMS, which till has not been applied in, but it comes under the part of future recommendations, where this paper is very useful in giving the users of LPS a better way to use the tool.

Appendix B

Interview Guide

1. Introduction to the interviewer
   Who and Where am I?
   Why this research question and for what reason?

2. Introduction to the respondent
   Your organization and Role in the organization and working in the construction industry since.
   Interview questions for each research question:

Interview questions based on the research questions are as follows:

1. How is the Last Planner System practiced in India/Norway?
   Current tools and methods used in a project to control and optimize.
   What are the different schedules used in LPS, how often is the meetings for discussing the plans?
   Who are all the main actors in the meetings, what are the things discussed and who coordinates with them?
   How is pull planning introduced in a site and how are the planning skills of the workers in the site?

2. What are the experiences gained from the implementation of the Last Planner

System?
What were the main challenges (social and organizational) experienced during the implementation?
Any significant changes caused because of LPS in terms of productivity, cost and reduction in cycle times?
Any challenges with communicating with the last foreman and feedback from the foreman on their ability to complete the promises after using LPS.
Do the clients know about LPS and if yes, what has been their feedback on using LPS in projects?
Did timely payments play a role in completion of activities?
Once the project is over with the usage of LPS, on what basis do you conclude whether it was successful or not?

3. Improvements that can be made in the future.
Thoughts about LPS in general
Apart from just LPS, any new tries for integration of other processes (for ex. LBMS, Takt time) with LPS?
Personal opinions about improvements in the process, any new approaches you think are needed?
Anything you would like to add.

Appendix C

Conference paper accepted for publication

THE LAST PLANNER SYSTEM: COMPARING INDIAN AND NORWEGIAN APPROACHES

Ramakrishnan Ravi, Ola Lædre, Roar Fosse, Kalyan Vaidyanathan, Fredrik Svalestuen

ABSTRACT

Construction projects around the world currently use the Last planner system (LPS) with different approaches. In this paper, we compare the Indian and Norwegian industry because of their contrasting cultural settings, in order to gather experiences and formulate possible improvements to their LPS approaches. A general literature study regarding LPS and its components was carried out. Data from two cases in India and six cases in Norway were collected with the help of three case specific and five general interviews.

The study revealed similarities in scheduling and planning, root cause and constraint analysis, PPC measurements (daily and weekly) during the meetings. The major difference was that the Indian companies use LPS as a problem solving technique in the middle of the project and the Norwegian companies use it proactively as a part of their system. A major conclusion drawn in the paper is that the participants felt more ownership to the schedule and the activities after the introduction of LPS. It became a promise of what they could do, rather than an order from the manager.

KEYWORDS

Last planner system, Hofstede Analysis, People, Culture and Change

INTRODUCTION

Poor project performance in construction is often related to factors like uncertainty or variability in workflow (Howell and Ballard, 1998; Ballard and Howell, 2003). The Last Planner System (LPS) was developed in order to reduce those uncertainties in the workflow (Ballard and Howell, 2003). According to Mossman (2014, pp.1-5), LPS intends to improve the reliability and predictability of the plans used for construction activities during the

implementation stage through an integrated approach. It has proven benefit on project performance for more than 20 years in multiple countries, across building construction, heavy civil engineering construction, highway and infrastructure projects, including ship building and pit mining (Liu and Ballard, 2008; Ballard, 1993; Ballard and Howell 2003; Alarcón et al. 2008). Engebø et al. 2017 found that, adjusted for the number of inhabitants, the interest for Lean Construction is much higher in Norway than in India. This correlates with previous experience of the first author from both the Indian and Norwegian construction industry and is a key motivation to compare the implementation of the last planner system between India and Norway, respectively.

In the following, the paper presents the main results from a literature review. Then a short explanation of the applied research methods is given. The findings and discussion part follows this, before the consequences of cultural differences between India and Norway are analysed. Finally, the paper presents conclusions on the three research questions.

LITERATURE REVIEW

The Last Planner System (LPS) focuses on planning and production control where the different components include master schedule, phase planning, lookahead (make-ready) planning, production planning, production management and learning (Ballard and Howell, 2003; Ballard, 2000; Mossman, 2014). An extensive study from Daniel et al. (2015) shows the different components of LPS used in 57 case studies across 16 different nations (including seven from Norway and one from India). Figure 1 gives an overview of the components that are frequently used. This case study has been used to identify the LPS components that are used around the world and it would be a good base to compare these with the actual components that are used in the Indian and Norwegian projects.

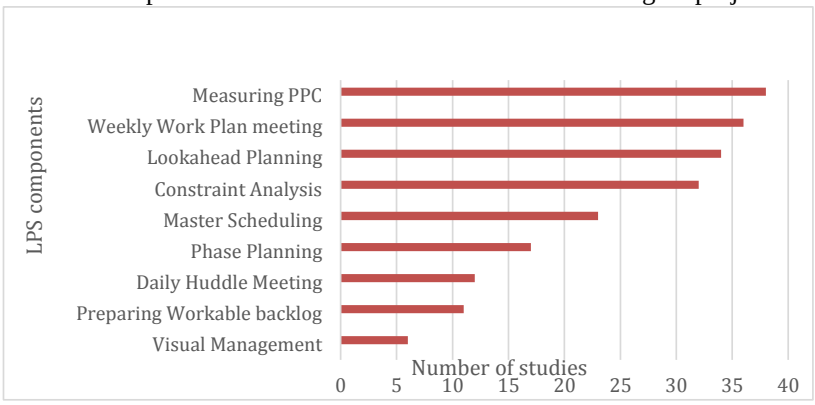

Figure 1: Some of the LPS components used in 57 cases (based on Daniel et al.2015)

A study from Johansen and Porter (2003) reveals that cultural barriers like attitude to work have a say when LPS is implemented. In an attempt to get a better insight in this statement, the authors have studied a cultural assessment field called Hofstede's cultural dimensions theory. Hofstede is perhaps more known in fields such as sociology and

psychology than engineering, but the authors argue that with culture and people being such a strong proponent of Lean practices, such cultural analysis tools could provide valuable insights into factors of success or failure of certain practices in certain cultural conditions. To help understand the difference between the cultures of countries, such as Norway and India, Hofstede looks to score them within six so-called cultural dimensions. First, **Power Distance** is "the extent to which a society accepts the fact that distribution of power in institutions and organizations is unequal" (Hofstede, 1980b, p. 45). **Individualism** is "the degree to which people in a country prefer to act as individuals rather than being a member of a group" (Hofstede, 1994, p. 6). **Masculinity** is "the extent to which the dominant values in a society are related to their assertiveness, acquisition of money and things" (Hofstede, 1980b, p. 46). **Uncertainty avoidance** is "the extent to which a society tolerates ambiguous situations and tries to avoid these situations by establishing more formal rules and believing in absolute truths" (Hofstede, 1980b, p. 45). **Long-term orientation** is "the ability of a society to connect the past with the current and future challenges" (Hofstede, G., 2011). Finally, **Indulgence** is "the extent to which a society allows relatively free gratification of basic human desires related to enjoying life and having fun." (Hofstede, G., 2011). Hofstede's cultural index has some limitations. For example, it presumes the whole population is equal, but not all sub-cultures and individuals necessarily fit into it. Nevertheless, the data collected is important as long as the context and content of the questions is phrased in the right manner (Clearlycultural.com, 2018). Critics claim that this model does not capture the complete phenomenon, as culture has more than six dimensions (Chao & Moon, 2005).

RESEARCH METHODOLOGY

The research questions in this paper are:

- How is the Last Planner System implemented in India and Norway?
- What are experiences gained with implementation in both the countries?
- What are potential improvements that could be made to LPS considering the cultural aspects?

A literature search for LPS theories and its components was carried in research databases, both with keywords and by using backwards snowballing (Wee and Banister 2016). This study has helped in identifying LPS components that are in theory and whether the same set of components are being used in the case study projects.

Two case studies from India have been studied, namely one Marine jetty project and one residential project. Nadhi Information Technologies, a consultant company facilitating contractors in India to implement LPS in their projects and having a lot of experience in implementing LPS in India, provided both these cases. Six residential, commercial and office building projects from Norway were also studied. Since, contractors in Norway have a longer history of Lean practices and a project management system inbuilt with LPS, more number of projects could be studied from two of the major contractors in Norway. Three cases were from Skanska and three were from Veidekke Entreprenør AS. The projects range from residential, commercial and office building projects. The lead author conducted a document study of documents received from the respondents. The Indian documents were mainly project details

(location, project cost, type of project etc.), changes caused in the project by implementing LPS, PPC measurements, productivity reports from site, cycle time charts etc. The Norwegian documents were mainly handbooks explaining their LPS implementation. The case studies were based on semi-structured open-ended interviews. The respondents were sorted in two categories, namely case specific respondents and generic respondents. In order to avoid bias, the respondents answered identical questions from an interview guide. By interviewing construction managers and LPS experts, different perspectives were accounted for. In total, four interviews were conducted in India and two in Norway.

With the help of the project data collected (changes in the LPS metrics) and the interviews with the lean experts (the extent to which different LPS components were implemented in the site), cross analysis was done. These findings were analysed with the help of Hofstede's six cultural dimensions to reveal the cultural enablers and roadblocks for implementation of LPS in both countries.

FINDINGS AND DISCUSSION

Since it was difficult for the authors to give a detailed explanation about each case and each interview, the information presented in the section below is an amalgamation of both the sources of data.

INDIA

The Institute for Lean Construction Excellence, India (ILCE – http://www.ilce.in) has been creating a basic awareness of lean amongst both mid managers and top executives over the past few years through seminars, workshops, education and running local chapters. There are high expectations on the results from lean and what it can achieve for projects (in terms or bringing delayed projects back on track and eliminating cost overruns). From the two case studies and the interviews general experience, a typical approach to implementing LPS in India is as follows: The need for LPS is felt a few months into project execution, when conventional approach has led to delays. There is pressure to bring the project(s) back on track. A third party lean consultant is hired to introduce the lean construction techniques (including LPS), does the site observations to understand the current condition of the project, report the "as-is" situation and a "to-be" intervention plan to the higher management. The Lean initiative is often kicked off at the site with awareness workshops and possibly simulation games (e.g. the parade of trade game) (Tommelein et al.1999). Then, the expectations from the site going forward is set by the third party consultant.

A phase schedule based on the contractual milestones is prepared, which is then broken down into a rolling 6-week lookahead schedule, weekly plans and daily plans as part of the weekly planning process. A weekly work planning meeting is held in order to plan the work that has to be executed in the upcoming week. The meeting is also used to discuss top delay reasons of the PPC and potential improvements. Daily Standup meetings of maximum 20 minutes are conducted to gather PPC and delay reasons, as well as discussing shared tools and equipment for the next day. There is a strong emphasis for crews not to focus just on completing their workload, but to generate adequate finished work for the trade behind them, to ensure adequate flow of work at a reliable pace. Since LPS is often implemented in the middle of Indian projects, there is often inadequate time and focus on

training up-front to properly establish the necessary culture and mindset. This often leads to participants initially struggling with common LPS skills such as clearly expressing what they need from each other, formulating well-described tasks, properly matching workload with needed labor etc. However, with time an increased schedule reliability and overall efficiency of the execution team have been observed in the studied cases.

There are also organizational challenges; for instance, if the lean consultant is hired by the contractors, the client might not endorse lean and understand the need for efforts such as removing constraints as part of the lookahead (make ready) process. This is partially because owners want the freedom to make changes until the end and partly because they also lack awareness of the lean process. There are also socio-cultural challenges, such as entry-level field engineers finding it difficult to say "no" to what they perceive as unrealistic requests from their managers. Even worse, they might be forced to give commitments that satisfy the expectations of management irrespective of the actual situation. One reason behind this, we postulate, is the Indian education system where students from their childhood are taught to respect elders and teachers (hierarchy) without asking questions. Therefore, lean consultants have to "unlearn" this habit to create an environment of freedom to say no.

Despite the mentioned challenges, the interviews identified some clear pockets of success in implementing LPS. One of the projects experienced a reduction of cycle time by around 40% (Vaidyanathan 2015). In the second case study also, the contractor experienced a 45% reduction in completion of coping beams in civil works. PPC on daily basis increased from 40% to 91% and PPC on weekly basis increased from 36% to 82%. The increase in PPC was due to the increased awareness of non-completion by introducing a rigorous application of Value stream mapping of reasons for those non-completions. A more significant intangible benefit was the recognition from the Client who noted that the contractor's ability to make and keep commitments had significantly improved in the six months after the adoption of LPS (Madhusudhanan 2017).

NORWAY

The Last Planner System seems to have entered the Norwegian industry around mid-2000s, with predominantly two large contractors incorporating it into their planning and control systems; Veidekke and Skanska (Kalsaas et al., 2009). Two major contractors in Norway - Veidekke Entreprenør and Skanska Norway – have LPS built into their project management systems. One reason of analyzing the LPS strategies of two different companies is to figure out the degree of similarity between them and the strategical differences in their system keeping the Norwegian culture in mind. These two contractors have a similar conceptualization and implementation of LPS, expect for the meeting structure. Employees get central training in LPS, as well as project-specific support during execution. Their planning hierarchies follow the theoretical prescriptions for LPS with master and phase scheduling, lookahead planning, making commitments, weekly and daily planning, tracking of progress and learning.

In terms of meeting structure, Veidekke has four weekly progress meeting. The first one focusses on workforce and subcontractors plan their weekly work plan. They have another meeting where the foremen and subcontractors make their 2-4 week lookahead

plan. In the third meeting, the site manager meets the project manager to discuss the 5-9 week lookahead schedule. In the fourth meeting, all subcontractors meet the foremen to discuss the work done that week by measuring the PPC and prepare work for the next week. For making work ready, they have an MS Project schedule linking every activity to each of the seven pre-requisites and a YES/NO column, whereas only activities with YES on all seven are ready to be included on the weekly work plan. If there is a problem regarding any of the pre-requisites, someone is made responsible for removing the constraints by Friday of that week. Incomplete activities in the PPC review are moved to the next week as a part of workable backlog. Skanska usually have two progress meetings per week for production work. One meeting involving participants from all the trades and one is for the foremen to coordinate. In addition, they have a daily job briefing, where each crew goes over their upcoming daily tasks, coordinates against other trades, material deliveries etc. The progress of the design schedule is quite thoroughly reviewed as part of the weekly Last Planner process described in Fosse & Ballard (2016). If needed, Skanska teams add other progress meetings, and often also a PPD (production-procurement-design) coordination meeting for the in-house managers. Skanska's most of the projects plan their on-site activities location-based in their pull-planning sessions as a part of LPS in their system.

LPS is out of many project participants' (especially the sub contractors) comfort zones compared to traditional planning methodologies. Many are used to having schedules created just for their trade and working in silos, without the rigorous coordination between trades and phases as LPS often promotes. From the interviews with the Norwegian practitioners, it was identified that there lies a challenge in managing people on different hierarchical levels looking at different time frames. For example, a manager (the leader) who looks two to four weeks ahead can disrupt the planning ability of a foreman who is used to look at (and good at coordinating) one week ahead.

LPS IMPLEMENTATION MATURITY MATRIX

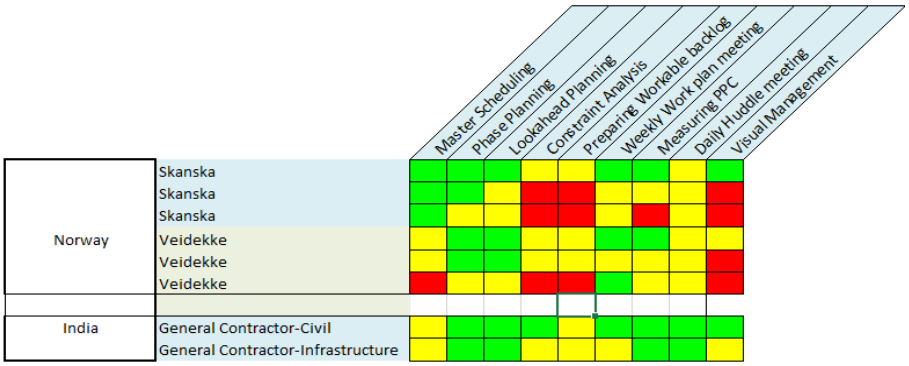

Figure 2: LPS Implementation Maturity Matrix

With the available case studies and interviews from the Indian and Norwegian side, an attempt has been made to summarize the implementation grade of the LPS components in the investigated cases from Norway and India. The colors presented in Figure 2 represent

the degree of implementation and these scores were given by the authors based on findings from the interviews and the case studies and these scores are subjective in nature. Green denotes that the practical implementation is similar to LPS theory, yellow to some degree or acceptable substitute practices and red denotes not corresponding at all. An important learning from the matrix is that the Norwegian projects, although having LPS incorporated in their systems, only use selected components on many projects. The Indian projects on the other hand, use almost all LPS components as described in theory, irrespective of a positive or negative outcome. The lean experts of Veidekke and Skanska experienced project success despite poor LPS implementation, as well as project failure despite successful LPS implementation. Therefore, it is difficult to directly correlate LPS implementation with project success based on LPS metrics.

HOFSTEDE ANALYSIS RESULTS

The Hofstede values of Norway and India are given in Figure 3, and they will be used to analyze the cultural reasons beind the usage of LPS components. These scores have been obtained from the Hofstede's cultural dimension scores for different nations and the website link for checking the scores has been provided in the references.

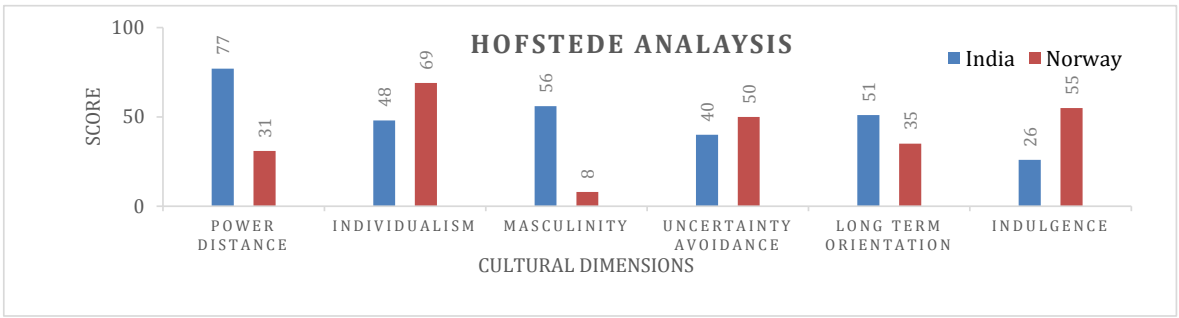

Figure 3: Hofstede Analysis results for India and Norway (Hofstede Insights, 2018)

Power Distance, India 77, Norway 31. An example would be socio-cultural challenges presented under the Indian side. This could indicate that Norwegians have a flat hierarchical structure, increasing their ability to say "no", which seems like a very important premise for reliable promises. This might explain why Norwegian contractors have LPS incorporated into their systems of standard planning practices.

Individualism, India 48, Norway 69. This factor relates to how the two countries see it natural to act as a single person or as a team. One way of interpreting this is that it should be more natural in India to appreciate LPS as a way of working as teams. An example would be the increase in the PPC shown in the Indian case studies, as it increased when people started to work more as a team, not just achieving individual goals.

Masculinity, India 56, Norway 8. This factor could be related to how decisions are made. Indians have assertive decision-making power within a few individuals of a group, while Norwegians might rather listen to all opinions before making collective decisions. This may cause that the pull-planning sessions in Norway are better to coordinate trades involved than those in India.

Uncertainty avoidance, India 40, Norway 50. This factor however could be related to how important it is for the teams to make work ready in a timely manner rather than accepting that not everything is in place before execution of work and making-do. Another example would be organizational challenges presented under the Indian side, where the owners hesitate to take responsibility on the work of Lean experts.

Long-term orientation, India 51, Norway 35. This indicates a better pre-condition for lookahead-planning in India than Norway. On the other hand, it might also indicate that India is more culturally prone to plan construction projects too much in detail too early, rather than following the LPS principle of planning to the right level of detail to the right time and accepting that things don't go as planned, but rather be able to change accordingly in an agile way.

Indulgence, India 26, Norway 55. This factor could be related to the social processes of LPS. Norwegians might be more comfortable with the informal tone and inter-personal communication often related to several components of LPS.

CONCLUSION AND RECOMMENDATION:

Looking at implementation experiences of the practitioners from the Indian and Norwegian industry, the need for cultural change to adjust to a new process such as LPS might take more time than anticipated by lean advocates. In terms of implementation, the findings from the interviews seem to correlate well with the Hofstede analysis of the two countries. Indian workers and entry-level engineers might struggle with saying "no" to their manager rather than giving a reliable promise because of the power distance. Norwegian contractors might have challenges coordinating people, as they can be individualistic in nature. Masculinity might lead to Indian project teams having a few strong individuals making decisions on behalf of the team, while a Norwegian team depends on group decisions. Furthermore, Hofstede's six cultural dimensions have been helpful in explaining the experiences related to different LPS components. For instance, lookahead planning should correlate with the ability to think long-term, constraint analysis should correlate with the ability to accept uncertainty. Based on differences between the Norwegian and Indian cultures, the potential improvements that could be made in order to improve the process that could involve change in their cultural ethos include:

- **Norway:** Use a Bottom up approach for LPS on the Norwegian side, where the subcontractors and foreman can be taught to plan for the next day in the beginning and a step by step increase to asking them to do the lookahead plan for 6-8 weeks. Indian counterparts could try LPS at two levels (learning from Norway): a short-term one that only involves coordination among contractors and a medium-term one that involves owners and contractors coordinating design and procurement.
- **Norway:** For the Norwegian counterparts to try other aspects of LPS and see if that leads to improved reliability and efficiency of project delivery. Particularly, the daily stand up meetings and value stream mapping is something they could try.
- **India:** The execution engineer, in India, or the person responsible for the activity should be given the freedom to say "No", so that he can make reliable

commitments. Owners should not involve in disrupting the planning ability of the contractors in the Indian side; they should be less "masculine" about it in the interest of the project. Regarding the Norwegian side, the foreman who has to lookahead plan for 6-8 week ensure that their actions do not disrupt the 1-2 week plan of the sub-contractor.

- **India:** Clients and management (especially in cultures such as India) should try to be less "masculine" and empower entry-level field engineers to have opinions. Subcontractors and foremen can be gradually empowered to increase their planning capabilities and responsibilities. Especially if just asked to do short-term daily planning, one could increase responsibility to do lookahead planning and have more impact on identifying and handling constraints.

All in all, both sides have something to learn from each other's successes (or lack thereof). And both sides have some room to improve their cultural baggage to improve the adoption of the principles of LPS and achieve better success in project delivery through the use of LPS. In general, the Lean Construction community should have even more discussions about the cultural pre-conditions of the countries, companies and project organizations where Lean Construction practices are implemented. There is a need for improved insight of what factors that enable successful adoption.

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