STATE OF PRODUCTION PLAN RELIABILITY– A CASE STUDY FROM INDIA

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ABSTRACT

In the quest to assess the state of production plan reliability on a mid-sized residential project in India, a case study is conducted with production planning inspired by Last Planner® System of production control (LPS). The residential construction sector in India is expected to grow at more than 26% per annum till 2014. However, India does not compare favorably with other countries in the efficient execution of projects and the government has pointed out the need to enhance productivity to meet the increasing rate of economic growth with the best use of labor and resources. Variability and uncertainty in construction project production is identified as an area of improvement.

In order to investigate the current state of production plan reliability on mid-sized residential construction projects, a case study is conducted on a 17-story residential project in Mumbai, India. The results indicate that initially, production plans prepared by the project team were highly unreliable with a high degree of variability, but they improved toward the end of the project. Production plan reliability measured as Percentage Plan Complete, also known as Percent Promises Complete, (PPC) varied from 25% to 100% over a period of 24 weeks.

The major reasons for production plan failure were bad weather, labor unavailability, material unavailability, untimely drawings and decisions, city regulations, government compliance and unplanned holidays. A feedback loop was put in place and project participants were interviewed at the end of the project. They reported improvement in production plan reliability and indirect cost and quality benefits. This case study provides a hint to the state of production plan reliability in Indian residential construction projects. However, additional and cross sectional research on a variety of residential projects is needed to statistically validate the findings and understand the current state of production plan reliability in India.

KEYWORDS

Last Planner® System of Production Control (LPS), Residential Construction, Production Workflow Reliability.

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INTRODUCTION

In India, construction is the second largest economic activity after agriculture. Investment in construction accounts for nearly 11 percent of India's Gross Domestic Product (Indo-Italian Chamber of Commerce and Industry 2008). The current size of the residential construction industry in India is estimated at approximately $44 billion, and it is expected to witness an annual average growth rate of approximately 26 percent till 2014 (Research and Market 2008).The industry, by its systemic nature (Fernandez-Solis 2007), is highly fragmented. The top 10 companies account for approximately 10 percent of the total revenue of the industry, while a major part is attributed to unorganized real estate builders (Research and Market 2008). Data from the Indian government and industry suggest that on average, each construction project suffers from 20 to 25 percent time and cost over-runs, while in some construction sub-sectors, such as commercial, this is as high as 50 percent and above (McKinsey and Company 2009). A need to substantially strengthen production planning and construction management is emphasized in McKinsey and Company's (2009) report. India's Eleventh Five Year Plan (Planning Commission -Government of India 2008) states –"*Introduction of efficient technologies and modern management techniques to raise the productivity of the (construction) industry is vital. A national strategy and policy framework, focusing particularly on (construction) productivity enhancement and cost reduction, is required to be developed to match the envisaged work load and delivery targets.*" In this report, the government calls for improvements to keep up with the current rate of economic growth (7% - 8%), as well as the desperate need for infrastructure development.

In addition to other productivity improvements, such as advanced equipment and improved construction methods, improvement in production planning is identified as an area of improvement. The first step to improve the production planning process is to understand the current state of these practices in the industry. Several academics and industry professionals within the international lean construction community have successfully implemented and demonstrated a reliable planning process using LPS on construction projects (Hill et al. 2007; Hamzeh 2009; Koskenvesa and Koskela 2005; Conte et al. 2002; Alarcón et al. 2008, AlSehaimi et al. 2009, Ballard et al. 2009, Ballard et al. 2007,Salem and Solomon 2006). LPS is designed to make construction production plans more predictable (Ballard 2000) by involving the last planner in the weekly decision making of how to make ready the work that is to be done that week. It also helps identify constraints on the work in the coming weeks and removes those constraints so that promises made are promises kept.

A very good example of lean implementation is demonstrated by projects undertaken by Sutter Health, headquartered in Sacramento, California. Sutter Health (a client organization), in collaboration with main supply chain partners, implemented LPS on five pilot projects (David Medical Office Building, Modesto 8 Story Bed Tower, Delta, Roseville Emergency Department, Roseville Parking Structure) as a part of the organization's lean initiative in 2004 (Ballard et al. 2007). After a series of experiments, LPS is now in use on all major Sutter Health construction projects (Hamzeh 2009).

In the case study project discussed in this paper, an LPS-inspired production-planning system was used to assess the current state of the production planning process in a mid-sized residential construction project. There was no effort made for detailed scheduling or for production workflow control using look ahead planning and constraint analysis. In other words, there was no master schedule or reverse phase schedule in place. Weekly work planning, percentage plan complete (PPC), reasons for non-compliance, and feedback loop LPS elements were applied to understand the state of production plan reliability on the project.

In the sections that follow, we first describe LPS and its functions. We then briefly discuss successful LPS implementations in other countries. A case study illustrates the effects of proactive production planning, followed by conclusions and discussion of lessons learned.

LITERATURE REVIEW

The Last Planner® System of Production Control is a procedure of creating a master schedule (or a phase schedule based on a master schedule), a look-ahead plan, and a commitment/weekly work plan through front-end planning using lean construction planning techniques (Howell and Ballard 1994). Weekly work planning is referred to as "commitment planning" because, at this stage, specific resource assignments must be made so that work can actually be performed.

Several case studies of LPS implementation have been documented by the lean construction community (and others) in the last two decades. Factors affecting the success rate and effectiveness of the LPS system have been studied/observed and documented.

Fiallo et al. (2002) studied the benefits of applying LPS on an 80,000 square feet, $860,000 residential project in Quito, Ecuador. In their study, the use of LPS resulted in a high level of commitment from production units. However, the authors also point out the lack of project stakeholders' commitment to LPS implementation, which resulted in unreliable production on multiple occasions during the 23 weeks of LPS application.

In another instance, LPS was applied on a 17 story residential building project in Fortaleza, Brazil (Kemmer et al. 2007). The author reports the positive results of look-ahead planning and benefits realized in analyzing physical flows, cost management and safety planning and control.

The literature shows that LPS training and pull planning by senior management and site crew are crucial to its success. Unfortunately, that didn't happen in the present case study project, due to a delayed decision to implement LPS.

RESEARCH METHODS

We conducted an empirical study to understand the state of production plan reliability on a mid-sized residential construction project in India. LPS was partially implemented, meaning weekly work plans were prepared and percentage plan complete (PPC) and reasons for non-compliance metrics were captured. Pull planning was not used. The production reliability data was collected for a period of 168 days (24 weeks), from August 2009 to March 2010. We monitored structural work, including four standard tasks: excavation, laying formwork, placing reinforcement and pouring concrete. The subcontractors reported their weekly plans to the project engineer who kept a record of the planning data.

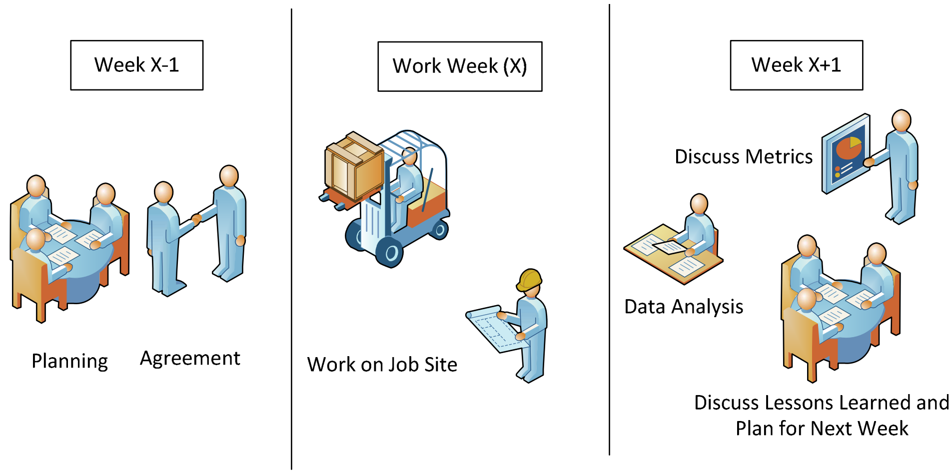

Figure 1: Production process at current case study project

The project engineer used the reasons for non-compliance data for feedback purposes in planning subsequent work. The reasons were discussed with key project participants (architects, engineers, builder, general contractor, and subcontractors) for planning the work for the next weeks. At the end of the data collection period, these project participants were interviewed to assess the effects of control practices and feedback loop on cost, schedule and quality. Figure 1 briefly shows the production planning process at the case study project.

CASE STUDY PROJECT DESCRIPTION

The case study project involved construction of the structural part of a 17 story residential building in Mumbai; India. It was a $4.2 million project with a total built up area of 50,000 square feet. The estimated project duration was 18 months. A cast in place construction method was used on the project, whereby concrete was mixed on site (not using a ready mix concrete plant).

In India, small business entities (generally called builders) typically construct medium sized residential buildings; a single business entity has contracts with architects, structural designers and general contractors. The builder is a business person who hires other contractors to do the job, while the builder generally deals with procurement, finances and government approvals. Architects and engineers are responsible for design and the contractor for construction. In this case study, the builder hired a general contractor for construction of the building. The general contractor, responsible for the construction management, hired labor and equipment subcontractors for the construction phase. There was a milestone schedule with due dates for critical activities such as slab pouring, inspection, close out, etc., but there was no detailed schedule in place. The work week consisted of seven, nine-hour days.

FINDINGS AND RESULTS

PERCENTAGE PLAN COMPLETE (PPC)

The PPC data on this project was highly variable. LPS was not used in the typical sense of stickies (PostIt™ notes) on the wall or weekly last planner meetings of foremen in charge of the work, but it was carried out by the project engineer getting input from field crew on what work would be completed during the current week and inquiring what work would be done in the coming weeks. Initially, the percentage of promises completed was low. But, after 14 weeks of data collection, and the understanding of performance gained by keeping promises, along with the positive feedback when promised work was fulfilled correctly, completely and on time, the PPC increased above 80% for a period of nine weeks. The average project PPC was a remarkable 77%, which requires some explanation.

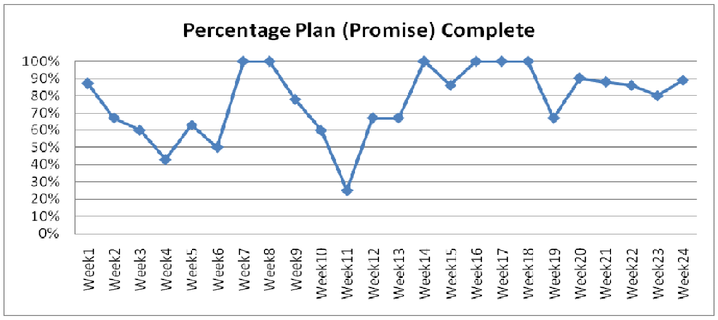

Figure 2: Percentage of Plan Complete over a Period of 24 Weeks (Calculated on Weekly Basis)

- In addition to planning initiatives, good weather conditions in the months of December to March and repetitive structural construction work (and less complex work) contributed to the PPC increase.
- Several tasks or assignments considered completed during PPC calculation were not complete on the day they were promised, but were completed in the same week. Generally, LPS recommends that task must be complete on the day it is planned. If completed the next day, even if it is the same week, it is not recorded as a YES (YES means the promised work is complete, correct and timely). Because of the use of different metrics, we are unable to make any valid comparisons with PPC on other lean projects.
- Another explanation for the 100% PPC towards the end of the projects that the project did not have a detailed schedule (master schedule); therefore, commitments were made on the run and not compared to what was planned at the beginning of the project. In other words, 100% promises complete is much easier to achieve when the promise is made the same week it is carried out; nevertheless, the promises were not completed on the day promised as noted above.
- Assignments did not necessarily follow quality criteria for a good plan as explained by Ballrad (2000). The assignments were selected in the proper sequence and were sound and practical, but good assignment definition and right amount of work selection for each assignment were not thoroughly understood and put into practice.
- The project PPC average contrasts with a study (Bhatla 2010) in India that reports average construction project PPC to be 55.84%, which is a more

reasonable comparison than comparisons to reported average PPC in the USA and in Europe.

- Senior and middle management planning for the project occurred rarely. These results imply that there is a huge gap between what senior management and middle management planned and what happened on the job site.

At the end of the project, we interviewed key project participants. They reported indirect cost and quality benefits due to LPS implementation. For example, the builder was able to procure aggregate in time based on proactive planning done by the field crew, thus shielding production from material strikes. Moreover, the builder was able to make quick and timely decisions for resolving constraints. LPS also helped in cutting down long chains of communication between different consulting parties (architects, engineers, etc.), thus establishing a reliable communication flow and collaborative environment. The project contractor reported improvement in the work culture and client satisfaction due to improved production control. The structural engineer for the project (who was also responsible for project control and monitoring) said that "*LPS can be successfully implemented on any project. For implementing such kind of systems in real life project we need a strong and good co-operation of our project team, which include the participation of executing team as well as top management team*."

ANALYSIS OF THE REASONS FOR NONCOMPLIANCE UNCOVERED IN THE PPC REPORTS

The case study analysis offers valid points of non-compliance that can be examined, analyzed and reasoned.

The reasons for non-compliance to plan data for the 24-week period are shown in Figure 3. Weather was the biggest reason for production unreliability (27%), with material unavailability and untimely delivery contributing 14% to production plan unreliability.

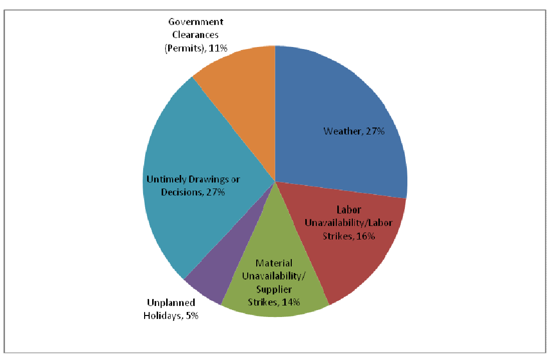

Figure 3: Reasons for Non-Compliance

Bad Weather

Bad weather conditions constituted 27% of the reasons planned activities were not completed. Due to heavy rainfall in the months of September and October, excavation work was affected. Heavy rainfall caused flooding on the construction site, preventing excavation work and causing landslides, also preventing laying of structural formwork, reinforcement and concrete pouring. This indicates that weather forecasts and annual weather patterns were not taken into consideration during the planning process.

Labor Unavailability

Around 16% of tasks were not done due to labor unavailability, disputes on wages, working hours and labor holidays, about which management was not informed, led to labor unavailability and incomplete work on weekly plans.

Materials Unavailability

Late delivery of structural steel and inadequate planning caused material unavailability on the site. Sand and aggregate for concrete was also not available due to strikes caused by increase in government taxes on these trades. Approximately 14% of reasons for non-compliance were attributed to material issues.

Unplanned Holidays

Unplanned holidays caused delay in some instances. Work was supposed to occur on certain days but holidays were announced by the project superintendent at his discretion. This contributed 5% of the total reasons for non-completion.

Untimely Drawings and Decisions

Another significant cause for delay was the unavailability of information on time. For 27% of the time, drawings were not available or decisions were not made in time. Change orders caused delay in architectural and structural drawings, resulting in incomplete tasks on weekly work plans. Project stakeholders failed to make certain decisions, such as column location alterations and elevator placement, which caused delays too.

City Regulations and Government Clearances

Government clearance (permits) on building blueprints caused delay in the project's progress. Eleven percent of the time, permit clearances were the cause of delay. Moreover, in a residential area, the city did not allow construction work during the night time, due to high noise levels causing disturbance to other residents in the area.

EFFECTS OF PRODUCTION PLANNING INITIATIVES

At the beginning of the project, the project participants (architects, engineers, builder, general contractor and subcontractors) were interviewed to understand their planning practices. It was determined that the general contractor and subcontractors did not prepare master schedules; instead, they used a milestone schedule. There was no formal production planning process on past projects and they were not planning to use one on this project. However, they estimated labor output and labor requirements for different project phases based on activities in the milestone schedule.

During a later stage of the investigation period, project participants were interviewed to see the effects of current control and monitoring practices. They pointed out the following benefits caused by the planning, controlling and monitoring practices used during this investigation:

- Higher degree of collaboration

- Material procurement on time, avoiding material unavailability during strikes
- Realization of the importance of planning and production plan reliability on construction project
- Decision making support for both onsite and offsite activities
- Learning from failures (lessons learned)
- Better control over schedules

CONCLUSIONS AND RECOMMENDATIONS

The empirical study reveals that production plans prepared by senior and middle management were unreliable with a high degree of variability. The large magnitude of disconnect between planning and execution, as seen from the PPC data, reveals a poor planning process. Major reasons for non-compliance to planned production were bad weather, labor unavailability, material unavailability, untimely drawings and decisions, city regulations, government clearances, and unplanned holidays. Following are the main observations from the project:

- Initial project production planning was unreliable, almost non-existent, but onsite adaptation of planning techniques improved dramatically toward the end—a situation attributed to the introduction of selected LPS tools and techniques on the project.
- A disconnect existed between the planning of tasks by senior and middle management and their execution. Planning is understood as command and control, and what is planned is expected to be identical to what is performed, which is not realistic in practice. LPS brings last planners (foremen and superintendent) into decision making about work to be done, and for removing constraints. In this case, the approach did improve onsite production performance as measured by the PPC.
- Project management did not anticipate common foreseeable schedule constraints, such as holidays and weather conditions. Some buffer for these highly probable recurring events should be anticipated on the project milestone planning.
- The project execution strategy was completely based on pushing the work to meet the milestone dates. There is no good understanding of the pull concept at this very early stage of LPS adoption; this item should be on the agenda for future projects.
- When a feedback loop was used, indirect cost and quality benefits were realized. This indicates that the production workforce is trainable and, when properly educated and directed, will respond to initiatives such as LPS. This offers hope for a more efficient industry use of labor and materials. Government clearances and issues such as labor and trade strikes are unique to the Indian construction industry. However, the metrics of reasons for non-compliance to the plan are similar to metrics from other countries.

LPS has brought benefits to project budgets, quality and safety in other countries, according to published literature. Making production plans more reliable is an opportunity at the strategic level of the owner and government programs. LPS is a tool that can be used to make production plans more reliable in India, as shown by this and other case studies, provided it is properly implemented with adequate training and strong owner, government and management commitment. Furthermore, LPS implementation can be improved with innovative ideas derived from the local work culture. That is part of on-going research on LPS implementation in India.

LESSONS LEARNED

All the components of LPS must be applied from the beginning of a construction project to understand the effect of production plan reliability on performance. Clearly, the current case study only partially implemented them. However there are benefits to partial LPS implementation and in circumstances as seen in Indian construction industry there is an advantage in starting with part of the system. By doing so we can engage the people on the ground that then helps to engage senior management and that in turn can promote the take up of the other elements of LPS. Further studies on the effects of production plan reliability on construction productivity in India will help clarify the effects of LPS and the potential benefits for this particular market and with construction idiosyncrasies of the socio-economic work culture. Pilot projects in other construction sectors (industrial, infrastructure, commercial, institutional, etc.) implementing LPS will provide valuable cross sectional data to help identify and analyze the potential advantage of using this new construction management technique in the Indian construction industry.

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