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The Last Planner System in China's construction industry — A SWOT analysis on implementation

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Abstract

The Last Planner System™ (LPS) is well-documented in the literature, and has sometimes been used to represent lean construction or lean project management. LPS aims to achieve reliable workflow by encouraging foremen to have a sense of ownership of the project programme and to build-in their commitment into it. This study reports on the perceptions of Chinese building professionals of the application of LPS in Chinese construction projects. It reveals that several components of LPS have already taken place in large Chinese construction firms. Further, this study employs a SWOT analysis to examine the possible strength, weakness, opportunity, and threat factors that might have an impact on implementation of LPS in construction projects in China.

Keywords: Last Planner System; Construction project; Implementation; SWOT

1. Introduction

The success of lean principles in manufacturing, and the benefits arising from its use, have led to the development of lean implementation in construction (Egan, 1998). Lean first emerged in the construction industry a few years after gaining full acceptance in Western manufacturing industries. Several authors have attempted to provide an account of the lean construction perspectives. One major contribution comes from Ballard (2000) and his colleagues on the creation of the Last Planner System (hereafter referred to as LPS). As its name indicates, in LPS the decision making is given to the "last planner" or foreman, so that he can add in details and commit to what can actually be achieved in the coming week (Ballard, 2000). More importantly, a collaborative environment of planning is fostered for the exchange of information about the progress being made on site among different trades and/or subcontractors during the planning exercise. The rapid development of this decentralized means of project planning has won recognition from practitioners all over the world. Reportedly, the implementation of LPS has been adopted in construction projects in various areas, including the US (Jesus and Leong, 2000), the UK (Johansen and Porter, 2003), South America (Fiallo and Revelo, 2002), the Middle East (Alsehaimi et al., 2009), Korea (Kim and Jang, 2005), and others. LPS has also been implemented in large and complex projects (Ballard and Tommelein, 2012) — for example oil refinery expansion (Liu et al., 2010), where it was reported that the use of LPS resulted in reductions in workflow variation, and thus helped to improve labour productivity. The other benefits of using LPS are documented elsewhere (Fernandez-Solis et al., 2012; Mossman, 2013).

Tapping into the above-mentioned benefits is certainly something that Chinese construction firms are striving for. The Chinese construction industry is currently experiencing a booming period, as the government unveils plans to invest in transportation, infrastructure, and rural development projects (ChinaDaily, 2013; Xinhua, 2008a). Driven by these ambitious plans, the Chinese

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construction market overtook the US since 2011 in terms of output (DavisLangdon, 2012). To maintain China's economic growth and to gain recognition for local officials, the government has been driving Chinese construction firms to build infrastructure projects quickly and to deliver on time (Bristow, 2007). One example is the construction of stadiums and venues for the Beijing Olympics, all of which were completed on time or ahead of schedule (PeopleDaily, 2007). As on-time project delivery is valued by clients in China, Ling et al. (2009) have advised Singapore's construction firms to focus on this and to commit to a quality schedule when they undertake projects in China. In contrast, the story is different when large Chinese construction firms operate overseas projects. Reportedly, a leading Chinese construction firm failed to deliver a mining project in Australia on time, and suffer about 3 years' completion delay and the associated cost overrun (Ng, 2013). There are problems associated with giving project delivery the highest priority. Given the pressure on delivery, projects are sometimes rushed, and quality is often compromised, leading to building flaws (Bristow, 2007). For example, the investigation into a bridge that recently collapsed in Northern China only after 10 months' operation revealed that the original plan for this bridge construction was to take 3 years (36 months), but the project had been completed within 18 months (Xinhua, 2008b) to comply with the client's requirement.

Based on the discussion above, LPS would seem to be a good candidate for project planning and control in Chinese construction firms. This paper sheds light on the application of LPS in the Chinese construction industry, with the primary aim of comparing the current practice of planning in China to LPS. This paper also attempts to understand the strength, weakness, opportunity, and threat (SWOT) factors associated with the implementation of LPS, so that strategies can be formed for better implementing LPS in the Chinese construction industry. This study is organized as follows: it reviews LPS in Section 2, including its origins, components, and recent development. Section 3 deals with the research methods and the interviews that form the basis of this paper. Section 5 examines the findings presented in Section 4 using SWOT analysis. Section 6 concludes the paper.

2. Review of literature

2.1. Origins of Last Planner System

Generally, LPS is closely associated with lean construction, and in some circumstances the term seems to be used as if it were synonymous with lean construction (Green and May, 2005). Perhaps LPS has achieved a greater degree of industrial penetration (Green and May, 2005). As illustrated in Fig. 1, LPS is perceived as one line of research, interpreting the application of lean production methods to construction (Koskela et al., 2002; Winch, 2006). Its goal is to create a reliable workflow by having the project team, including all affected firms, collaboratively create a phase plan for each segment of the work (such as the foundations). This is a social process involving discussion with site staff and also planning to ensure that work is not waiting on workers, and that workers are not waiting on work.

Alternatively, Fig. 1 shows a conceptualization of lean construction from the early work of Koskela (1992), who termed learn construction the "new production philosophy" of the construction industry. Koskela (2000) synthesized three different perspectives (transformation, flow, and value generation) on the construction process, which formed the foundation for what has now become known as lean construction. These two schools of thoughts represent the basis of lean construction. The coexistence of different interpretations of lean construction has also been observed by Green and May (2005), who have pointed out that "*lean construction can be interpreted as a set of techniques, a discourse, a 'socio-technical paradigm' or even a cultural commodity*" (p.503).

2.2. Components of the Last Planner System

LPS is now regarded as the most powerful and well-known planning and control system of all the lean construction techniques and tools (Kenley and Seppänen, 2010). According to Ballard (2000), LPS builds on the principle of systematic reactive work planning executed on the lowest possible level in the hierarchy of planners – the last planner. The underlying philosophy is to ensure that all the prerequisites needed to perform distinct construction work are in place before they are assigned to a work group (Ala-Risku and Kärkkäinen, 2006; Ballard, 2000). It uses the overall project plan as the general framework, but suggests that the daily activities of production should be managed by a more flexible approach that is cognizant of the actual progress of the project. According to Ballard (2000), there are four main categories for any executable project task, namely SHOULD, CAN, WILL, and DID (see Fig. 2):

- SHOULD: tasks that need to be performed in the near future, according to the overall project plan. What should be done actually involves a push mind-set, on the basis of which, project tasks are pushed to execution. The works that should be done to achieve staged milestones are among some of the good examples that fall in this category. These "should-be-done" work items are derived from multiple sources, including the project objective, information, client input, as well as planners' past experiences.

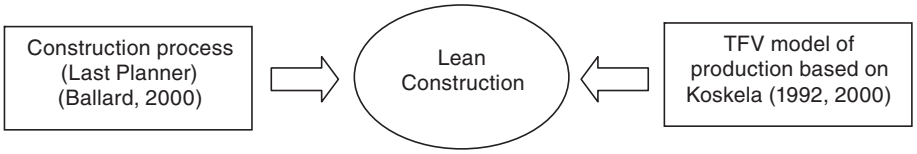

Fig. 1. Two core interpretations of lean construction.

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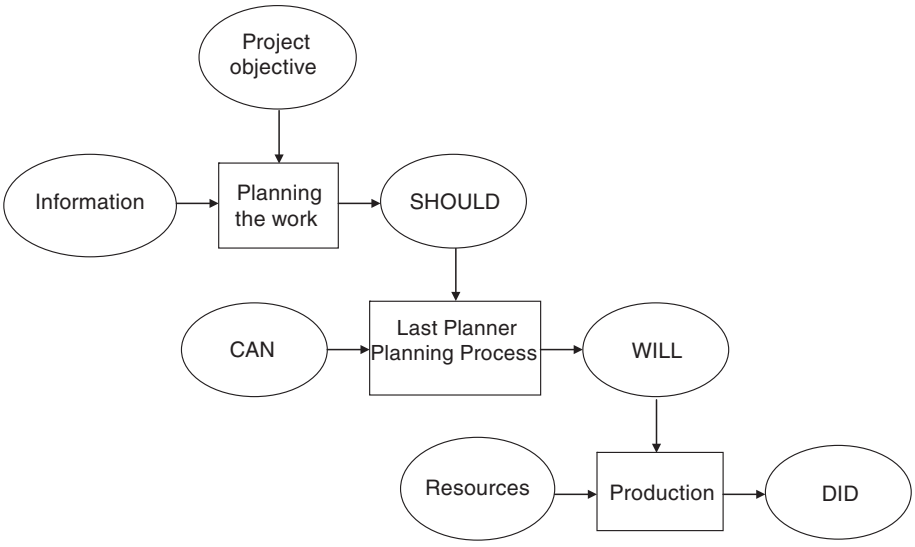

Fig. 2. The Last Planner System. Source: Ballard (2000).

- CAN: this process involves adjusting what SHOULD be done to what CAN be done. Efforts need to be made to screen tasks that have all their prerequisites ready—that is, where previous project steps are completed, the necessary materials are at hand, and the workforce is available. Only when all constraints are removed, can the tasks be allowed to proceeded, if the plan's reliability is to be improved.
- WILL: the tasks that are commenced before the next planning round.
- DID: the tasks that have been completed.

Moreover, LPS employs a four-level hierarchy of schedules and planning tools: the master plan, the phase (pull) plan, the look-ahead plan, and the weekly work plan (Ballard, 2000; Kenley and Seppänen, 2010).

2.2.1. Master and phase plan

The master schedule is the overall project schedule, which is developed from the design criteria and supports the client's project objectives. It consists of milestones and items with long lead times. Milestone dates are determined by using the "pull" process from successor milestones (Ballard, 2000). The plan is then developed by those responsible for building the phase together with subcontractors, starting backward from the planned phase completion date (Kenley and Seppänen, 2010). The process reveals what must be done to release work for production.

2.2.2. Look-ahead plan

The Look-ahead plan represents an intermediate level of planning. It is a schedule of potential assignments, typically for the next 6 to 8 weeks (Ballard, 2000). The number of weeks over which a look-ahead process extends is determined by project characteristics, the reliability of the planning system, and the lead times for acquiring information, materials, labour, and equipment (Ballard, 2000). The work is planned on assignment level, which means something that can be communicated to workers (Kenley and Seppänen, 2010). Management continues to break down the activities into more details and screen the resulting smaller activities throughout the look-ahead window, until the activities are essentially assignment-level tasks.

2.2.3. Weekly work plan (WWP)

The weekly work plan is an assignment-level schedule. Detailed schedules are derived from the look-ahead plans on a weekly basis. The WWP is formed based on the mechanism of LPS, which aims to transform what SHOULD be done into what CAN be done (see Fig. 2), thus forming an inventory of ready work. In the meanwhile, examination of the prerequisites can take place when this level of detailed schedule can be achieved (Kenley and Seppänen, 2010). A typical weekly work planning procedure proposed by Ballard and Howell (1998) should follow the principles including definition, soundness, sequence, size and learning. In addition, to review the previous weeks' work plan against what they have been promised in one earlier week is another important agenda during weekly meetings. LPS projects would rely on *percent plan complete* (PPC) to reflect the progress. More importantly, they would record the quantity and reason for any variation of each tasks on the weekly work plan.

2.2.4. Percent plan complete

This is another key feature of the LPS, which tracks what is known as percent plan complete. It is calculated by dividing the number of completed assignments (what "did" get done) by the total number of assignments each week (what was projected "will" get done) and reasons are identified and acted on for failures to complete assignments. A high PPC means that the LPS allows for reliable forecasting of work, and that tasks made ready are being completed on schedule.

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2.3. Practical and theoretical development

Numerous cases of LPS use have been reported on in terms of the system's claimed benefits (Nieto-Morote and Ruz-Vila, 2011). According to Fernandez-Solis et al. (2012), more than 200 projects using LPS have been reported since 1996. A majority of these studies have been published at the International Group for Lean Construction (IGLC), an online portal for lean construction researchers and practitioners. Apart from the adoption of hierarchical structure in LPS, several variations of LPS have emerged. For example, Wambeke et al. (2012) used LPS in conjunction with a risk assessment matrix, in order to prioritize the most challenging causes to variation identified in the weekly meeting. Seppänen et al. (2010) discussed the use of LPS along with location-based management systems.

Recent developments of LPS have also witnessed attempts to explore its theoretical basis. From the management perspective, Kim and Ballard (2010) have argued that LPS appears to reflect manage-by-means (MBM) thinking rather than manage-by-results (MBR) thinking. Kim and Ballard (2010) explained that the belief underlying MBM is consistent with three features of LPS, including (1) LPS is focused on planning reliability, not on financial metrics; (2) LPS assumes that scheduling tasks involves uncertainty and constraints; (3) management decisions are based on planning reliability. Moreover, since learning from past failure and successes is an important process within LPS, it naturally connects well with Deming's PDCA cycle on a continuous improvement basis. After the completion of the assigned tasks each week, it is more important to carry out reflection on the PPC indications, seeking root causes for non-completions, collecting positive or negative feedback from the last planners, and continuously improving the planning process for the next stage. This exercise drew scholars to establish links between LPS and learning theory (Kalsaas, 2012) and knowledge management (Skinnarland and Yndesdal, 2012). Both mentioned that LPS is capable of contributing to the process of creating knowledge in construction projects if the evaluation plans and the uncovering of the underlying reasons for failure to complete tasks as planned are properly conducted.

2.4. Implications for project management

From a broader perspective, LPS is regarded as an important tool for lean project management (Ballard and Howell, 2003), and is particularly relevant to project time management – one of the nine areas underpinning PMBOK (PMI, 2008). LPS takes the work breakdown structure to decompose the project into detailed and workable tasks at the operational level. The difference lies in who should play the critical role in project plans. PMI (2008) does not explicitly outline who should be responsible for project planning. In construction projects, it is commonly presumed that it should remain in the hands of the project managers or planners. However, LPS encourages a bottom-up way to engage the foreman or last planner to take ownership of planning and control, and argues that, since last planners are closer to the site, it is more appropriate that they provide input into weekly plans. In addition, the complexity of project and uncertainty are also acknowledged as a way to encourage learning and to trace the root causes of the reasons behind the non-completion of tasks. This is in line with constraint analysis, as described in PMI (2008). Since LPS is becoming popular and recognized as an innovative project planning tool, it is an area worth exploring and recommending to the existing portfolio of project management practices adopted by Chinese building professionals, which already includes quality management (Zeng et al., 2003), risk management (Zou et al., 2007), procurement management (Shen and Song, 1998), and other approaches at the project level.

3. Research methods

3.1. Method design

This present study is part of a larger research project, which aims to give better insight into how lean principles can be implemented in the Chinese construction industry. The data used in this study were derived from field work conducted in China. This study only reports on those portions of the findings that pertain to project planning and control, with a focus on the implementation of LPS within large Chinese construction firms (LCCFs).

The qualitative method was considered appropriate, as this study is exploratory in nature and the LPS concept may be new to Chinese building professionals, being rarely reported in the Chinese construction industry. Thus, in order to obtain an in-depth understanding of how this concept being used in China, the possible opportunities and constraints would appear to be crucial. The research has been undertaken in several stages. To begin with, the extensive previous literature review has provided an overview of LPS and its implementation. Secondly, in-depth interviews with 27 experienced Chinese building professionals from 16 large Chinese construction firms were conducted between February and May of 2011. There were two main purposes of these interviews in this study:

(1) To investigate the current planning methods adopted by Chinese building professionals using the LPS standard;
(2) To identify the factors behind the implementation of LPS in the Chinese construction industry. SWOT analysis was performed at this stage. Included in the data instrument were questions on the interviewees' views on factors affecting the implementation of LPS.

3.2. Data collection

Data were collected through various channels, including interviews, casual and formal on-site observations, and internal project documents. In-depth interview discussion with Chinese building professionals was also utilized. This is in line with the recommendations of Churchill (2001), who suggested that this method is best suited to exploratory research. The effectiveness of the interview as a preferred method has been documented elsewhere. These in-depth interviews can provoke discussion of complex topics, and they provide rich and complete data

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(Easterby-Smith et al., 2008). In addition, interviews allow researchers to control the response environment, control the order in which issues are discussed, and learn about things that can be observed only with difficulty. In addition, site visit data were used as a form of triangulation. Several firms gave special permission for the first author to visit their sites and to sit in as a non-participant observer during weekly meetings sessions. This observational data provided additional material on which to base the emerging conceptual categories and additional evidence of recurring themes.

3.3. Interviewees

27 semi-structured interviews were carried out during the fieldwork. The interviewees consisted of 17 site staff and 10 management staff. The number of Chinese building professionals that participated in this research may be considered a limitation. Nevertheless, many studies that have investigated the Chinese construction industry have also encountered similar limitations, and some of these qualitative studies had sample sizes smaller than 30 (Chen et al., 2009; Lu et al., 2009). The approach adopted in this study is however in line with suggested guidelines for recommended sample sizes in similar qualitative studies. Charmaz (2006), for example, suggested that 25 participants are adequate; while Green and Thorogood (2004) opined that the experiences of most researchers are that in interview-based qualitative studies, little that is "new" comes out of verbatim transcripts after the researchers have interviewed 20 or so people. The management staff were considered appropriate subjects, given that they all had on-site experience (including planning) prior to their promotion to managerial positions in the head office. For those members of the site staff who are currently involved with construction work, although they were given different designations, they had experience in planning, typically because the project team on site was small, and every team member worked extensively with planning issues. Detailed descriptions of the sample interviewees are provided in Table 1.

As indicated earlier, this study only exhibits the relevant information pertaining to planning and control (i.e. the use of LPS) from a larger fieldwork, with a focus on understanding of how LPS operates within Chinese construction firms, and to understand the SWOT factors to LPS. This is covered in the interview protocol with four broad topic areas:

(1) What levels of project planning are adopted?
(2) Who is the Last Planner at the project?
(3) How reliable is project planning (e.g. weekly plan)?
(4) What are the barriers to LPS implementation?

4. Findings

4.1. Level of project planning

Table 2 illustrates the levels of detail in terms of project planning at the firms interviewed.

4.1.1. The master/phase plan

Table 2 indicates that the master plan, along with the phase plan, is available in nearly all the firms interviewed. The master plan is a mandatory requirement in the contractual agreement that is drawn up between the client and the main contractor prior to the award of the contract. One project manager from Firm D noted that:

> "*The master plan incorporates inputs from client's team in which a few key deadlines (milestones) are clearly set. However, the master plan is of little value in guiding the daily operations because it only defines tasks at an abstract level. In most times, the master plan is more useful for use in claims for delay against the client.*"

This is in agreement with Ballard (2000), who indicates that there is no need to plan in detail at this stage (so-called front end planning). In addition, the phase plan is derived from the master plan, and is used to guide the work of phase package. The Project Manager from Firm M mentioned that his current project does not have a phase plan, given that the project appears to be relatively simple and he has undertaken similar projects many times. Moreover, as pointed out by most interviewees, financial incentives are linked to the completion of phase plans. Normally, when each major phase of a project is completed on time, the client will fulfil its promise in the contract in terms of financial incentives.

4.1.2. The look-ahead plan

Unlike the master plan, a 6-week look-ahead plan was absent from almost all the firms interviewed. Technically speaking, the regional manager from Firm I is the only interviewee who had real-life experience in, and understanding of, what a look-ahead plan is and how it works. As revealed by this regional manager, the look-ahead plan was requested by the client's specialists when the firm undertook an overseas project in Singapore. A look-ahead plan aims to establish a plan that contains weeks of workable backlog and identifies the constraints and activities for the 5 weeks of the project. This interviewee also revealed that, in the Chinese context, a look-ahead plan has an equivalent term called a monthly plan, which is more prevalent. Indeed, all the firms interviewed adopted a monthly plan for project planning in the short term. Generally, a monthly plan comprises 4 weeks' work plan, and provides good look-ahead views for tasks that need to be completed in the coming month. Nevertheless, the existence of monthly plans does not mean that construction firms in China are practising the essence of LPS. The look-ahead plan provides a baseline for future weekly plans, and needs to be flexible and dynamic (Ballard and Howell, 1998). As the look-ahead horizon changes, the look-ahead plan needs adjustment. However, compared to look-ahead plans, monthly plans prove to be less dynamic and less rigorous. The chief engineer at Firm C revealed that, in most cases, a monthly plan is produced on day 1, and no further attempts are usually made to update it, even if changes occur.

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Table 1
Profile of interviewees and firms.

No.	Code	Designations of interviewees	Company grade	Ownership	Location of interviews/ projects	Budget (RMB in millions)	Estimated project duration (stage)
1	A*	1 Project Manager	Premier	SOE	Beijing	180	n/a (Final)
2	B*	1 Engineer-in-Charge	Premier	SOE	Beijing	599	370 days (superstructure)
3	C*	1 Engineer-in-Charge, 1 Site Engineer, and 1 Commercial Manager	Premier	SOE	Shanghai	680	980 days (superstructure)
4	D*	1 Project Manager, 1 Managing Director 1 Contract Manager	Premier	SOE	Wuhan	1235	1025 days (Stage II)
5	E^	1 Project Director 1 Deputy manager	Premier	SOE	Hangzhou	n/a	n/a
6	F^	1 Manager 1 Head of Engineering Management Department 1 Project Manager	Premier	SOE	Shanghai	n/a	n/a
7	G^	1 Vice President	Premier	SOE	Beijing	n/a	n/a
8	H^	1 Manager	One	SOE	Beijing	n/a	n/a
9	I^	1 Regional Manager	Premier	SOE	Beijing	n/a	n/a
10	J*	1 Project Manager	One	Private	Shanghai	130	490 days (close to handover)
11	K^	1 Vice President	Premier	SOE	Nanjing	n/a	n/a
12	L*	1 Site Engineer	Premier	SOE	Wuhan	34.5	730 days (Stage II)
13	M*	1 Project Manager	Premier	Private	Hangzhou	218	400 days (foundation)
14	N*	2 Project Manager 2 Site Engineers	Premier	Private	Hangzhou	240	670 days (second floor)
15	O*	1 Site Engineer 1 Quality Engineer	Premier	SOE	Hangzhou	12,000	1095 days (foundation)
16	P*	1 Project Manager	Premier	SOE	Hangzhou	2200	750 days (superstructure)

Note:
(1) 27 interviewees in total.
(2) General contractors in China are graded into Premier Grade (highest level), Grade One, Grade Two, Grade Three and below.
(3) SOE (state-owned enterprises) and private firms are two common forms of ownership of Chinese construction firms.
(4) * Denotes that the interviews were conducted at project site.
(5) ^ Denotes that the interviews were conducted at the firm's head office.

4.1.3. Weekly plans and weekly meetings

A weekly plan was adopted by most interviewees at the project level. Interviewees from only two of the firms interviewed (Firms M and N) stated that they used a two-weekly plan instead of weekly plan, as their clients desired to be updated on the project's progress every 2 weeks. As revealed by most interviewees, project managers and chief engineers have a significant role to play, usually based on their past experience with similar projects in determining weekly plans. This is consistent with the findings of Johansen and Wilson (2006), that past experience is one of the principal sources for project plans. Aside from that, some interviewees also mentioned that, before the weekly plan is finalized, it is necessary for the planning team to consult with the foreman and subcontractors about the availability of resources, the constraints of their current work, and other factors. This so-called preliminary meeting invites the foreman and subcontractors to sit down to discuss what needs to be accomplished in the coming week. This is done in a less formal meeting on a weekly basis, prior to a more formal meeting, in which the project team updates clients on the project's progress. The decisions or agreement on assignments will then be announced during the weekly meeting, in which all relevant parties should attend. According to the interviewees, a weekly plan generally consists of three parts:

- Overview of jobs/tasks that have been completed in the past week.
- Overview of jobs/tasks that need to be completed in the coming week.
- Analysis of the root causes for the schedule delay and associated countermeasures.

According to several interviewees, some level of consensus on these three parts would be reached among all the parties. However, this form of weekly plan suffered from a lack of details regarding the assigned job, as compared with the weekly plan designed in the Last Planner System. Also missing was information on the "detailed contents of daily tasks", "who is in charge", "potential hurdles that might affect reliability", and so on.

4.1.4. Huddle meeting

16 out of 27 interviewees outlined that there were short meetings held on a daily basis by the project team at the start of

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Table 2
Adoption of LPS.

Firm	Master plan	Phase plan	Look-ahead plan	Weekly plan	Huddle meeting	Critical roles in the planning process	Reliability of plan
A	√	√	X	√	Daily	• Project Manager (PM) • PM needs to constantly consult with foremen and subcontractors.	• Fairly good
B	√	√	Monthly plan	√	Daily	• PM	• Fairly good, but sometimes delays occur because of design variations.
C	√	√	Monthly plan (seldom update)	√	Daily	• PM and Project Engineer (PE)	• Fairly good
D	√	√	Monthly plan	√	Daily	• PM	• Fairly good, as milestones can be achieved, but the course to achieving it may be different to what is in the planned schedule.
E	√	√	Monthly plan	√	Daily	• PM makes request to subcontractors to review their own weekly plans.	• Fairly good. If a delay occurs, PM makes a request to the subcontractor to engage more resources in order to make up the lost time.
F	√	√	Monthly plan	√	Daily	• PM has a critical role in producing the plan, but it requires the parent company (e.g. the Planning/Estimating Department) for approval and documentation. • Subcontractors submit their weekly plans for PM's approval and reference.	• Reliability is good. However, constant minor adjustments are needed but acceptable.
G	√	√	Monthly plan	√	X	• PM	• Fairly good
H	√	√	Monthly plan	√	X	• PM is in charge, and consults with subcontractors who need to feedback information on resources, weather, etc.	• Fairly good
I	√	√	5 weeks ahead + current week	√	Daily	• PM	• Good
J	√	√	Monthly plan	√	Weekly	• PM	• Not very certain about the reliability of weekly plan. Sometimes it is ahead, while sometimes it is behind the schedule.
K	√	√	Monthly plan	√	Weekly	• PM is in charge, and consults with the foreman of each trades.	• Fairly good
L	√	√	Monthly plan	√	X	• Full time staff from headquarter • Planning/Estimating Department is stationed at the project site.	• Relatively good. Sometimes it will get ahead of schedule by completing unassigned jobs.
M	√	X	Monthly plan	Bi-weekly plan	X	• PM	• OK. Often the schedule is affected by material and labour shortage.
N	√	√	Monthly plan	Bi-weekly plan	X	• PM needs the subcontractor's agreement on the work contents and target set in the given week.	• Labour shortage at the moment, so there is a slight delay.
O	√	√	Monthly plan	√	Weekly	• PE is in charge and is required by PM to submit the plan for his final approval.	• Generally good. If delay occurs, PM will request subcontractors to engage more resources to make up the lost time.
P	√	√	Monthly plan	√	X	• PM • The ultimate purpose of a weekly plan is to inform not only the project team, but also the frontline workers.	• Generally good

Note:
"√": Implemented.
"X": Not implemented.
"PM": Project Manager.
"PE": Project Engineer.

a workday. The purpose is to convey the daily goals established during the weekly meeting to the entire workforce. Issues relating to health and safety, drawing variations and others will also be addressed. These interviewees stated that a similar type of meeting was also held at the end of each workday to review what had actually been completed and to discuss the potential constraints that the team might encounter the next day. In addition, some mentioned that in their projects, huddle meetings were only conduct at the beginning of each week to address important issues, while there are six interviewees mentioned that they don't have huddle meeting at all. One project manager explained that: "*we don't need it as we are*

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busy enough, and the communication is also straightforward at site."

4.1.5. Percent plan complete (PPC)

It is understandable that in any project, most activities have some leeway or "float" that permit them to start at a late time. Properly controlled, this float is valuable in regulating the use of workers, materials, and other resources. As part of the lean construction tool, PPC is widely used as one key matrix in lean construction for measuring and monitoring variations in the weekly plans (Ballard, 2000). When asked whether PPC or other forms of matrix were employed to monitor schedule reliability, a majority of the interviewees stated that these were not adopted. On the contrary, the use of PPC was criticised by one of the interviewees, a senior manager of Firm F, who said that:

"*In the Chinese construction context, PPC can only be done in the research setting. It is not likely, for my firm at least, to apply this tool even though it sounds theoretically feasible. This is because not only are management efforts always inadequate on site, but also the pressure of tight schedules do not allow us to conduct such work in a quantitative way*"

Several interviewees stated that although such a matrix was not used at the moment, general constraint analysis was performed on a weekly basis (at the weekly meeting) to analyse the causes of variations that may affect the upcoming weekly plans. The chief engineer from Firm C reflected that in his current project, weekly plan was produced in EXCEL worksheet, where there is a "remark" column that records the possible reasons to uncompleted tasks as planned in the first place. These will be discussed during the weekly meeting.

4.2. Critical roles (Last Planner)

As shown in Table 2, of the 16 firms interviewed, 14 firms expected their project managers to play "critical roles" in making a project plan. Clearly, project planning cannot be done as a one-man effort. About half of the interviewees highlighted that it was essential to consult with subcontractors or the foreman (concerning, e.g., the availability of resources, site constraints) and to integrate work plans into the project team's plan. One engineer pointed out that sometimes the project manager was so busy that he or she might not really be involved in the planning process at all, but was nonetheless expected to review and approve the schedule prepared by his or her direct subordinates (namely, the engineers). A majority of interviewees mentioned that no-one in particular is employed to deal with planning. In most cases, either the project manager or the engineers double up on the planning role. There was one exception to this, in Firm C, where the project manager mentioned that in his current project (a megaproject), a full-time planner from Firm C's headquarters is stationed on site when the project team is assembled. This implies that project managers and their teams are still in charge of project planning at the project level. The plans will later cascade to the foremen and from there to the frontline workers. In the end, it is the project manager who makes the final decision on what the weekly plan should look like. Moreover, it is rare for the foreman or subcontractor to reject the project manager's proposal. Instead, they need to hammer out a solution based on the weekly plan announced, that is, to make the necessary modifications to their own plans.

4.3. Reliability of work plans

No matter how well the weekly plan is prepared, most interviewees agreed that a highly reliable weekly plan was not easy to achieve. This is because site conditions are so unpredictable that the weekly plan is sometimes delayed by 1 or 2 days, which are then postponed to the following week. Such a delay calls for immediate action, such as deploying more workforce and other resources or working overtime to get the project back on schedule as soon as possible. One interviewee from Firm J explained that:

"*It is always like that (being behind schedule). As long as the milestones in the critical path are not affected, this sort of schedule slippage is acceptable. We understand it is not uncommon that extreme variation will cause our workers not to complete the job on time. Most of the time, it looks like this:* one *week we are a bit ahead of the schedule, and the next week some tasks have slipped to the week after. Overall, we are always in the middle of re-planning the project, re-estimating the time, and re-adjusting the resources accordingly.*"

4.4. Overburden

Apart from LPS, issues relate to overburden were also addressed during the interviews. Given that labour is still in high demand, the workforce on site have no choice but to work longer hours to keep the project on track, without which there is only a slim possibility of achieving timely completion. Therefore, it is very common to see workers having to work on the weekend, sometimes having only 2 days off in a month. Even during the holiday period (e.g. Chinese New Year), excessive overtime remains prevalent. As a result, the client is assured that the project progresses well, but *muri* – the uneven work – is frequent and obviously ignored by most firms interviewed. This seems to suggest that the workforce is undervalued and is often treated as a machine, rather than as the industry's most important asset. A possible explanation could be that the desired deadline for completion is unreasonably short in comparison with a normal schedule based on employees' benchmarked productivity. Several interviewees also attributed this unreasonable pressure from the client in the industry's unregulated environment.

5. Discussion: SWOT

In this section, SWOT analysis was used to reflect on and summarize the implementation of LPS in the Chinese construction industry. SWOT is a well-established research tool, widely used in strategic planning and refers to Strengths, Weaknesses, Opportunities, and Threats. According to Chermack and

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Kasshanna (2007), SWOT analysis can be a rich tool that helps explore new possibilities and initiates new programmes. Given that LPS is a relatively new concept in the Chinese construction industry, the use of SWOT seems an appropriate analysis tool. Based on the findings presented above, the SWOT factors for the implementation of LPS in the Chinese construction industry are summarized in Table 3.

5.1. Strengths

5.1.1. PM's planning skills (S1)

As learnt from the interviewees, in most cases project plans are developed by the Chinese project managers or chief engineers, rather than by "empowering" the last planners with planning responsibilities. A majority of interviewees gave credit to the project managers or chief engineers for their efforts in planning the projects. Their rich experience and solid understanding of the project provides them with confidence and the capabilities for dealing with planning. One interviewee recalled that, since he and his project team had completed housing projects (which he described as "homogeneous" in nature) so many times, a project plan could be easily produced to guide the site operations. Owing to their planning skills, project delay is less likely to occur, at least so long as the subcontracted teams are willing to follow instructions and plans. Even better reliability planning can also be achieved if such strengths can be properly utilized, for example, in tandem with the PM's willingness to consult the relevant parties for constructive discussions and reliable inputs.

5.1.2. Hard-working attitude and commitment (S2)

Apart from their good planning skills, the workforce in China also plays a major role in contributing to on-time project delivery. Arguably, the industry is filled with unskilled construction workers, yet some are hardworking and willing to obey their supervisors in order to get a slipped schedule back on the right track as quickly as possible. As discussed earlier, LPS requires commitment in delivering what was promised for the coming week, while having commitment in place but lacking the hardworking attitude will easily turn the commitment into an empty promise. As was learnt from the interviewees, in most cases – even though projects fall behind the original plans – overtime hard work would quickly put the project back onto the right track.

Table 3
SWOT factors of LPS implementation in Chinese construction firms.

Strengths	Weaknesses
• PM's planning skills (S1) • Hard-working attitude and commitments (S2)	• Poor capabilities of trade foremen (W1) • Not ready for commitment (W2) • Slow updating of planning information (W3) • Unwillingness to expose problems (W4)
Opportunities	**Threats**
• Willingness to consult (O1) • Basic elements of LPS are in place (O2) • Fostering long-term relationship with subcontractors (O3) • Role of Supervision Company (*jianli*) (O4)	• Lack of trust in frontline foremen (T1) • Demanding clients (T2)

5.2. Weaknesses

Despite these strengths, we can see some notable weaknesses in terms of the LPS implementation of large Chinese construction firms.

5.2.1. Poor capabilities of trade foremen (W1)

The first, and perhaps greatest, weakness is the poor capability of trade foremen – the "last planners". It has been indicated that subcontractors or foremen (of trades) in the Chinese construction industry tend to concern themselves with the scope of their own work, thus failing to see the bigger picture of interacting with other trades or teams. The workforce, led by its foreman, performs by simply completing the given tasks within a fixed time. Several project managers have considered engaging their foremen in the planning process, but this ended up with poor efforts, because most foremen or supervisors are not qualified to analyse where they presently are, in order to identify the constraints. One project engineer from Firm C commented that:

> "*Those foremen or trade leaders basically have no idea of where they are now in the flow of work. Therefore, it requires the PM to extensively coordinate between different trades to minimize (space) conflicts, idle times, etc. In most cases, it requires us to employ a top-down plan, rather than doing it in a bottom-up way.*"

5.2.2. Not ready for commitment (W2)

Another weakness concerns the readiness of foremen. As discovered in the interviews, foremen do not seem ready to engage in the planning process, as they are not yet comfortable with taking on responsibilities rather than taking orders. According to one project manager from Firm M, if foremen and their crews fail to complete the tasks listed in the weekly plan, they can easily argue that the fault lies in the unreasonableness of the given plan, while if they were asked to make a commitment to a weekly plan to which they had contributed, they would have no excuse to take but suffer certain consequences if a delay occurs. Such a mind-set prevents them in taking the initiative in terms of planning.

5.2.3. Slow update on planning information (W3)

The project teams have mostly ignored updating the project progress status, as well as planning its contents in the meeting room. This is especially true for the monthly plans. For visitors, this often leads to confusion. For workers, as well as the relevant parties, slow or no updates on the schedule reflect poor visual management and communication skills. It seems to imply that the site manpower is also lacking, or that the busy schedule leaves them no time to follow up on this.

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5.2.4. Unwillingness to expose problems (W4)

As indicated earlier, learning is an important social element of LPS. It is not uncommon to see problems emerging repeatedly in Chinese construction projects. Although in some occasions, these issues are addressed in weekly meetings, the root causes are uncommonly explored (Gao and Low, 2013). According to Gao and Low (2013), one possible reason for this is that when the weekly meeting is conducted with clients or clients' representative, the contractor would usually not be willing to expose their weakness in the area of project planning – even though they are aware that the project is slightly delayed. This unwillingness to reveal the root cause, on the one hand hampers the process of learning and understanding the causes of delays, but also affect project planning – as similar issues will be faced with again in the future without a proper strategy for tackling them (Hamzeh, 2009).

5.3. Opportunities

The preceding interview findings suggest several opportunities for the implementation of LPS in the Chinese construction industry.

5.3.1. Willingness to consult in terms of inputs (O1)

It is assuring to see that some of the PMs interviewed have noted that the information they use to construct staged plans comes from the foremen and/or the supervisor of the subcontractors. It is worth noting that, taking inputs from people who actually work on the frontline is essential to LPS. What is even more important is that such exercises should be carried out on a more transparent and frequent basis.

5.3.2. Basic elements of LPS in place (O2)

As is revealed during the interviews, a hierarchical planning structure has been adopted (i.e. a master plan, phase plans, monthly plans, and weekly plans). Having these basic elements in place is a good starting point for facilitating LPS implementation as a whole package, and guides their implementation in a more structured way. Presently, what firms may need to consider adding into the existing structure is a matrix (i.e. PPC) to measure the plan's reliability in order to understand more about the actual performance of weekly operations. If a poor PPC result emerges, it may quickly trigger follow-up investigations and reflections, as well as promote learning for improvement.

5.3.3. Fostering long-term relationship with subcontractors (O3)

Although not specifically discussed, the larger fieldwork undertook by Gao (2013) revealed that a long-term relationship with subcontractors is highly valued and desired by some of the interviewed Chinese construction professionals. Having such partners can further facilitate LPS implementation, because LPS requires much communication and coordination between various parties, as the aim is to work better than a temporary team just assembled for a one-off project. This is the case because it takes time to train the subcontractors in LPS and to cultivate the "learning" environment, if they are new to or unfamiliar with LPS.

5.3.4. Role of supervision company (jianli) (O4)

Both Wang et al. (2009) and Zuo and Zillante (2007) have noted that, in China, the work of construction supervision (*jianli*) must be carried out by independent supervision firms, according to construction law. According to Zuo and Zillante (2007), supervision engineers are responsible for supervising the work of the construction project, including project schedule, quality, and safety from beginning to completion. Arguably, the competency of supervision engineers may not be satisfactory (Wang et al., 2009). However, there is an opportunity that LPS can be used as one planning and control tool by the supervision firm to help the construction firms track the performance data when project personnel claimed to be busy and to lack time to do so. With the assistance of supervision engineers, working in a collaborative way, such extra assistance can help to promote LPS implementation.

5.4. Threats

5.4.1. Lack of trust in foremen (T1)

One key prerequisite for LPS is to build an environment of trust and collaboration (Mossman, 2013; Pavez and Gonzalez, 2012). Trust comes from the reliability of the weekly plan and from trustworthiness – not from commitments or contracts (Kim and Ballard, 2010). However, in the Chinese context, some interviewees seemed to show little confidence in what is promised by trade foremen in terms of the work that needs to be done by a certain date. One senior manager from Firm F added:

> "*…even though the foremen might have made 'realistic commitments' in delivering what they call the 'can-do' work assignments, due to uncertainties and changing site conditions, they would eventually fail to get the work done. I personally have no confidence in what they have committed to.*"

Such sentiments clearly indicate that mistrust does exist between project managers and the foremen or "last planners". On the one hand, a possible reason for this could be the foremen's weak planning skills. On the other hand, the workplace culture in China, in which project managers seldom empower foremen to take ownership of plans, might be to blame. As Mayer et al. (1995) have written, trust represents a willingness to engage in risk-taking with the focal party. It seems that the Chinese project manager rejects doing so simply because, if plans made by the foremen do not work out and subsequently lead to delay, it is the project managers and their teams who bear the pressure from the client, and this may in turn affect the "trust" between the project team and the client, which is the last thing that project managers are willing to risk.

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5.4.2. Demanding clients (T2)

Clients are sometimes demanding in terms of project delivery. For example, clients drastically reducing project delivery time is common in the Chinese construction industry. Even large construction firms are helpless but to accept this, because they are afraid of jeopardizing their relationships with their clients. In order to deliver the project on time under such pressure, the "locked milestone" strategy is widely adopted for specific portions of projects. This gives subcontractors and specialized trades locked deliverable dates in which to complete the work. If the work is not completed, large penalties are imposed. In cases like this, some interviewees have pointed out that it is not possible to "pull" the work from the workers: the majority agreed that their commitments on this point are unreliable. Hence, a top-down approach is preferable, in which the plan is generated by the project team without considering any concerns of the frontline workers and foremen.

The client's demand for timely completion of the construction project was another barrier cited to the adoption of a bottom-up planning technique such as LPS. Several interviewed firms revealed that they were under enormous pressure to produce a project plan using scientific planning principles. For example, the manager of Firm F explained that:

> "*A domestic private client requires us to deliver a project of 530,000 m^2 in 18 months. If we do not take this job, the client will find a replacement easily. In a case like that, if we were to adopt the LPS and to encourage the foremen to make commitments to completing workable tasks, we would never expect the job to be done on time. It must be a 'top-down' approach to enable the project team to design and to optimize the job sequence, and we must give the trades immovable deadlines, by all means also providing any assistance to help them finish the work within the given time.*"

In addition, the same interviewee introduced a so-called "bottom-line" management concept in her project, in order to ensure timely completion, as required by the client:

> "*… for example, a curtain wall package for one specialty subcontractor. What I mean by 'bottom line management' is that the curtain wall subcontractor is only given "windows", as well as the latest completion time (the bottom line) for the execution of their responsibilities on site. They have no choice but to complete the job before the deadline. If the job is delayed, assistance will be provided accordingly.*"

5.5. Strategies

The gaps in the planning ability of project managers and foremen prevent collaborative planning, such as LPS, from being implemented in the Chinese context. Currently, there is a one-way flow of scheduling information from the PM's team to the frontline workers. In order to better achieve the aim of levelling out the workload, as well as obtaining more reliable working plans, the strategies below are proposed:

- Following the existing structures of project planning, which are widely adopted within LCCFs, attention can be paid to the following aspects: (1) updating weekly plans and look-ahead (monthly) plans in a timely manner whenever unexpected events occur; (2) communicating these updates and changes to frontline workers in a timely manner through their supervisors, in order for them to understand where they are and what the follow-up actions are.
- In the long-term perspective, trust should be established between foremen, supervisors, and contractor's employees. The foremen and supervisors need to be trained to understand where they are in the flow of construction work, and where the project is heading. They should also be encouraged to participate in the planning process, and at least to provide key information and commitments in the weekly plans. This should be carried out in an open, understanding, and trusting atmosphere.
- As PPC is not very much practised by Chinese building professionals, an opportunity to track and possibly improve the reliability of the weekly performance is being missed. It is recommended that this matrix be integrated into any existing tracking system. Moreover, root causes should be revealed and lessons should be learnt, which can then be used as the basis for the next week of planning and for better implementation.
- Adopt appropriate motivational strategies to maintain the core workforce, at least until the project is completed. High turnover in the workforce can severely affect the workload to be levelled. To understand the capacity of the workforce, efforts should be made to alleviate the burden on the workers (such as overtime), which can fuel discontent.

6. Conclusion

The Last Planner System is known as a production planning system designed to produce predictable and reliable workflow, but has not been much discussed in the context of the Chinese construction industry. This paper is arguably one of the pioneering studies to investigate the implications of LPS for the planning system employed in Chinese construction firms. By reviewing the current project planning practices at Chinese construction projects, this study uncovers several areas of common ground between LPS and the Chinese way of project planning. Structurally, both contain similar hierarchical components for the different levels of details for plan needs.

However, several crucial elements of LPS, the look-ahead plans and PPC in particular, were not commonly seen in China. Apart from the technical aspects, the most significant difference appears to lie in the soft factors: for example, Chinese PMs do not empower foremen to take ownership of project planning with commitments built in. Having identified these differences, the SWOT analysis was carried out to investigate potential factors that might impact LPS implementation in China. The

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internal (i.e., strengths and weaknesses) and external conditions (i.e., opportunities and threats) of LPS implementation in the Chinese construction context were presented in this study. There are several positive factors that could facilitate the implementation of LPS, such as the solid planning skills of the PMs, accumulated from their past experiences with similar projects, and the hard-working attitude as well as commitment of the labourers. Excellent opportunities also lie in the willingness of the PMs to consult the inputs of the foremen when they are in charge of planning work, and when the basic elements of LPS are already in place. A long-term relationship with different crews and suppliers, who could be involved in planning and provide day-to-day checks on status, and the role of *jianli*, are also important. However, there are significant weaknesses and external threats that could hamper the adoption of LPS. The main threat comes from the lack of trust between the PMs and the foremen, and from demanding clients who unreasonably shorten the project duration and thus made the planning work more challenging. Weaknesses include the poor capabilities of foremen, who are not ready to commit to reliable weekly plans, and their unwillingness to expose problems. What is also lacking here is that planning information is slowly updated, and such poor communication and visual management fails to provide timely information, and can hence affect the project progress.

To remedy these weaknesses and to overcome the threats identified, construction firms in China should take the appropriate actions, and based on the SWOT factors, several strategies for better implementation of LPS can be proposed. These are considered as managerial implications. For example, it is observed that the existing structures of project planning are observed, but that the adaptation of other critical elements of LPS (such as PPC and look-ahead plans) be considered, as these are currently absent from the Chinese construction industry. Alternatively, it is suggested that trust, motivational strategies, and the other soft preconditions for LPS be established for better LPS implementation.

This study also encountered some limitations. Firstly, it is difficult to obtain more than a single interview with large Chinese construction firms. The reliability and richness of the results would be improved if more participants were involved. Secondly, although qualitative inquiries were made concerning the relevance of LPS in the Chinese construction industry, in-depth cases demonstrating how LPS could be implemented and the possible benefits derived from LPS implementation are still lacking. Nonetheless, the second limitation provides research opportunities for future studies. In addition to this exploratory study, which has investigated the possibilities of LPS in China's construction industry, in the long term, it would be beneficial to perform a longitudinal analysis of the impact of the Last Planner System on project performance. Moreover, comparative studies between projects using LPS and those with conventional planning systems, or between different types of projects (e.g., civil engineering projects and building projects) would also be able to generate interesting results that would contribute further to the knowledge of LPS implementation.

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