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Research paper

Application of last planner system with BIM in construction plan management

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Abstract

The project team maintains workflow continuity as much as possible to deliver products on time. Nevertheless, poor construction management makes the workflow unstable during the construction process, which leads to the delayed delivery of the building. As different methods to improve production efficiency, Lean Construction and Building Information Modelling (BIM) have a positive impact on the industry. Although many researches have shown the unique advantages of the Last Planner System (LPS) and BIM Technology, the advantages of their integration have not been fully exploited. This paper explores the application of the LPS and BIM in the construction phase through a project that transforms from traditional construction process planning to the use of the LPS. The project results show the impact of the LPS and BIM as lean methods on the project, which can improve the workflow of the construction project by improving efficiency and coordination.

Keywords: *Last Planner System; Building Information Modelling; Planning; Coordination.*

1. Introduction

As a production planning system, the LPS can improve the reliability of planning and reduce the variability of work in programming, design, construction and commissioning of projects [1], [2]. The LPS tries to eliminate the limitations of the critical path method (CPM) which only focuses on activity and duration while damaging the flow [3], [4].

The Lean Construction Institute (LCI) defines LPS as "the LPS is composed of 5 elements：(1) The master schedule identifies the objectives of the phase schedule and defines the major deliverables for construction, fabrication, and procurement, (2) The Phase schedule is more detailed to help the project team allocate staff, materials, and budget,(3) The function of forward plan is to improve the reliability and process of work, and to ensure that the workflow matches the resources of staff, materials and funds, (4) The weekly work plan is made by the production supervisor and foremen, updated daily (5) Continuous Improvement: measuring the metrics developed for planning work in order to find problems and make improvements in time, repeat the process. " [5]

Building Information Modeling (BIM) provide a sharing information platform which allocated resources between various trades for reducing variability in workflow [6], [7]. BIM Technology enables all members of the project to work together as a team on the same model, so that they can arrange meetings according to this mode, prevent information duplication, and complete the work faster [8].

Some researches showed that the collaborative application of LPS and BIM can effectively improve the performance of building projects [9], [10]. Nevertheless, there are few researches on the collaborative application between LPS and BIM in construction projects. Therefore, the authors of this paper expect to prove how the integration of LPS and BIM can improve efficiency and reduce waste in construction projects through additional empirical results.

2. Case study

2.1. Project introduction

The authors worked on a building construction project that implemented application of the integration of LPS with BIM. The project was Shandong Institute of cancer control and prevention which was located in Jinan City, Shandong Province, China. The project scope consisted of fifteen-stories above ground and two-stories underground, covering an area of 87592 square meters. The construction project team has one general contractor and thirty-two subcontractors, and the maximum number of field crew is about 1700 at the same time.

2.2. LPS with BIM in the lean construction process management

At the outset, when the construction phase was managed in accordance with the traditional planning mode, the construction manager made the master schedule and arranged the tasks of various disciplines, and tried to control the process. However, in the early phase, there have been some bad effects, as follows:

2.2.1. The handover and requirements of work were not clear

Tasks appear to be poorly described and not in the best order. And some members of the project team felt that they don't have the right sense of responsibility for each other's tasks.

2.2.2. The completion time of the task plan was not recognized

Early stage of construction, team members thought there wasn't enough time to complete construction tasks. As a result, the deadline has been extended. But a few weeks later, something similar happened again.

2.2.3. Low weekly task completion

Due to the low level of work done each week, the design team seems to be consistently behind schedule. The project manager felt that the reason was poor planning and control.
The project manager allowed lean manager to establish an information planning system to plan and manage the production process. The Lean manager decided to adopt the LPS system and believed that the task should be filled in the sticky notes and hung on the wall to arrange the task reasonably. Similarly, the BIM Technology was used to simulate the construction plan in advance to eliminate the possible problems.
According to the lean principle, the project team decided to use the combination of BIM and LPS to manage production. The application framework of BIM / LPS was established by the project team in order to better combine BIM Technology with LPS to improve project schedule performance, as shown in Fig. 1.

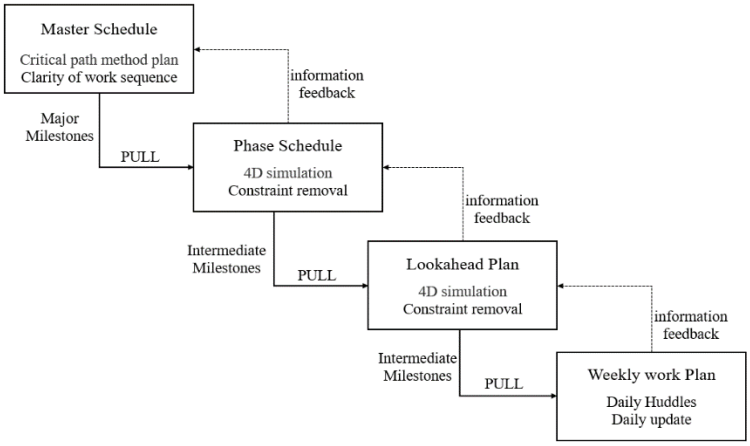

Fig. 1: The Application of LPS with BIM.

2.3. Key points of application

2.3.1. Adopting BIM technology

BIM technology was used to detect conflicts between structures and equipment, electrical, and plumbing (MEP) in the traditional manners. However, our lean manager had expanded the use of BIM in other issues. In the project, 4D simulation was used to determine the amount of material required and identify problems that may be encountered in the process of work execution. In the weekly meetings, the project comprehensive information and task completion were showed in a BIM model. Each task is replaced by a different color in the model and shared in the presentation in the form of pictures, as shown in Fig. 2.

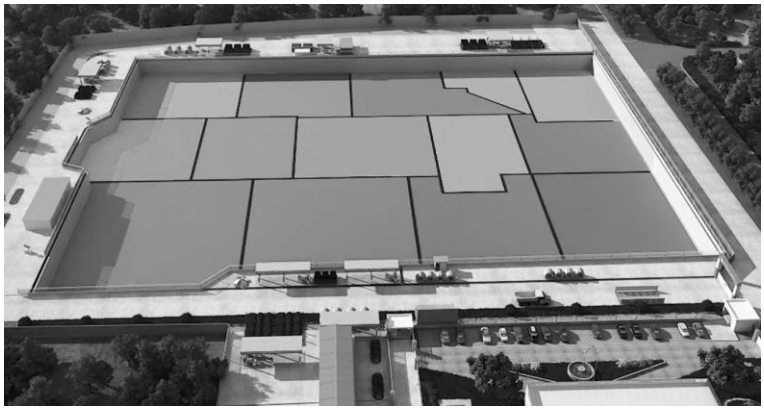

Fig. 2: Different Colors in BIM Model Represented Different Task Modules.

2.3.2. Using metrics for management

At the beginning of the project, some project team members resisted the Plan Percent Complete（PPC）and thought it was only a standard to evaluate individual performance. Through a series of training sessions, lean manager explained the advantages of PPC as a metric, set up PPC score system and introduced this correctly in the project. Keeping score as an metric evaluated which extent a team performed as committed. Tasks anticipated (TA) is a metric used to improve lookahead planning practices in the successful construction to increase the reliability of anticipating tasks [11], [12].

2.3.3. Planning meetings

One of the important concerns raised by lean manager of the project was to clearly the meeting agenda which included planning discussions and coordinated discussions in other parts of the meeting for avoiding lengthy arguments. Every Tuesday afternoon, the construction manager, superintendents, and foremen met to plan work in the conference room. The planning discussions focused on a one-month forward-looking plan. With hearing the foremen' ideas, the project team split and optimized the forward-looking plan to a weekly task plan. The coordination discussion included three parts: task completion check, unfinished task optimization and next week task optimization. The lean manager also supported the adoption of virtual interactive conferencing video systems to expanded the scope of meetings by involving those who can't be physically present.

2.3.4. Using sticky notes to arrange tasks

We used sticky notes as the representing of the task arrangement, which included two parts: the "commitment" represents the planned task and the "requirement" represents the conditions required to complete the task. In the project, the Yellow sticky notes represented the planned tasks, the blue ones were completed normally or ahead of schedule, and the red ones were the unfinished or delayed tasks. Sticky notes were posted on the display board at the task completion time to visualize the task handover time, which helped to manage material purchase and security by indicating when and what to do, as shown in Fig 3. Every member of the project team checked their sticky notes to make sure the front-end tasks are at the front, and generated other new sticky notes based on coordination meeting.

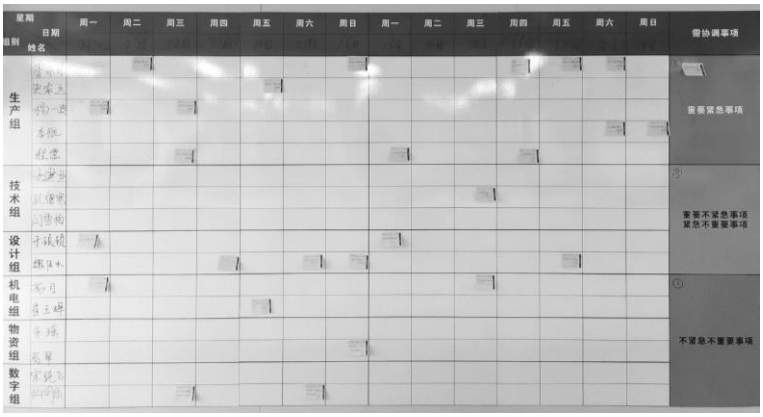

Fig. 3: Sticky Notes Representing the Task.

3. Results

With LPS and BIM practicing, project team members learned more about what they were going to build and understood importance of interdependence. The foremen became willing to share space with the following trade toward the end of their designated time and realized they didn't need to add a time buffer for each activity. Twelve-day durations shrunk to nine days in each of the four areas on each floor of the hospital project. Four out of 179 requests for information were related to a field conflict, and only two conflicts needed change orders. By planning the meeting agenda with specific issues, some trades can quickly participate and leave afterwards to reduce the staff spending time in meetings and improve the work efficiency. The average meeting time of the participants was reduced to 1.5 hours. When their crews failed accomplish the task, the foremen would choose from a predefined list of reasons for failure to complete. Having this list allowed the project team to see patterns indicating persistent issues and to develop a solution to them for facilitating task completion. With the implementation of LPS, the average PPC reached 76.2% (Fig. 4), the tasks anticipated (TA) metrics was 67.9% in the above-ground structure construction phase.

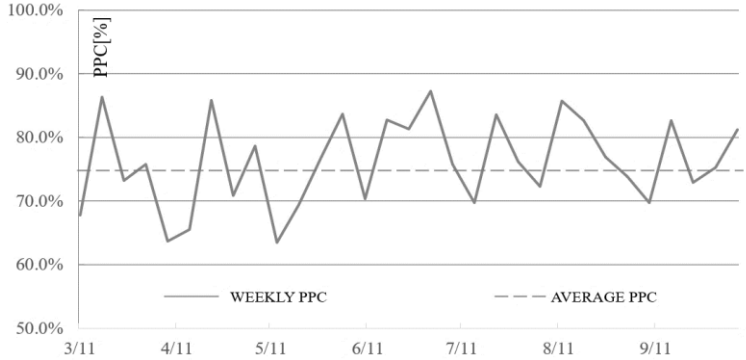

Fig. 4: The Line Chart of Weekly PPC of 31 Weeks.

4. Lessons learned

In the early phase of implementing the last planner system, as always, the project team had a good plan for what to do in the recent, but might forget the more distant future. In addition, team members may have been implementing several tasks before the planning meeting, which were not filled in sticky notes, resulting in inaccurate statistics of the number of planned tasks. Based on the observation of the implementation of LPS and BIM in the project, we determined that we should improve the following items:

- The 4D model should be divided into an entire year and a one-month process simulation to show the granularity levels of different construction sequences;
- Display boards had to be provided on site to show information about the plan and construction progress;
- All foremen related to the key tasks of construction should be involved in planning meetings, whether by videoconferencing or face-to-face communication;
- The planning meeting minutes should record who is responsible for an issue to track the commitments made, and should be quickly posted promptly for team members to access;
- The project managers should walk with the superintendents and foremen to see construction with their own eyes;
- In addition to implement of PPC, managers and foremen for the project should consider tasks anticipated, which is an important metric of removing constraints affecting production for the foreman getting them done in the following week as committing.

5. Conclusions

The LPS provides the project team with a s more optimized production system that authorizes every foreman to have a voice with their suggestions, make and implement solid commitments. The LPS integrates core management factors of task and process to enhance the cooperation of construction task planning, improve the reliability of workflow in construction phase. The use of LPS indicators can evaluate the performance of the project as a whole and participants involved, and make the project team see opportunities for improvement.
The 4D modeling, which effectively communicates the desired construction sequence to all participants, enables the project team to get project information in time. The use of BIM improves the ability of the project team to visualize work and reduces the waste in terms of looking for work.
Application of BIM can gain benefits align with the benefits of the LPS, so it can enforce many requirements and advantages of LPS while combined application. Therefore, the combined application of BIM and LPS can optimize the overall construction of the project, taking into account not only quantifiable indicators (such as PPC and TA), but also factors such as workflow and collaboration quality. The empirical results of this paper showed that the integration of BIM and LPS provide great potential for improving the process performance of construction projects.

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