CASE STUDY: AN APPLICATION OF LAST PLANNER TO HEAVY CIVIL CONSTRUCTION IN KOREA

Yong-Woo Kim[1] **and Jin-Woo Jang**[2]

ABSTRACT

The Last Planner is a production planning and control tool used to improve work flow reliability. Many companies have adopted the principles and reported the results of the case studies. The lean construction and the Last Planner principles have recently been introduced in Korea. Some companies in Korea are trying to adopt the Last Planner as their production control tool. However, they often face difficulties in applying the tool to their sites for a variety of reasons. The application can encounter some resistance when applied to the sites that contain different planning and organizational systems. These barriers make the application of the Last Planner to the country with a greatly different culture, interesting.

This paper introduces case studies of two heavy civil construction projects, along with descriptions of the ways that the Last Planner was applied, and how the work flow reliability was improved. It also discusses the prerequisites and barriers to implementation, of the Last Planner, in heavy civil construction projects in Korea. The results can be used as a reference for companies to improve their work flow reliability for future projects.

KEY WORDS

The Last Planner, Heavy civil construction, Production control, Work flow reliability

INTRODUCTION

The Last Planner is a production planning and control tool to improve work flow reliability. Many companies have adopted the method and reported the results of case studies. It was found in many reports and academic papers that the Last Planner improved the work flow reliability, thereby reduced the duration and cost (Fiallo and Revelo 2002, Ballard 1999, Ballard et al. 1996).

The lean construction and the Last Planner principles have recently been introduced in Korea (Kim 2000). Some companies in Korea are trying to adopt the Last Planner as their production control tool. However, they often face difficulties in applying the tool to their sites due to a variety of reasons. Some of reasons come from organization and cultural problems. The purpose of this paper is to present the barriers to implementation of the Last Planner in heavy civil construction in Korea and to propose possible solutions. This paper introduces case studies of two tunneling projects, along with descriptions of the ways that the Last Planner was applied, and how the work flow reliability was improved. It also discusses the barriers to implementation of the Last Planner in heavy civil construction projects in Korea. The possible solutions are then proposed. The results can be used as a reference for companies to improve their work flow reliability for future projects.

LAST PLANNER

Ballard and Howell (1994) proposed a shielding concept in planning called "Last Planner" to shield workers from the uncertainty of work flow. The "Last Planner" is the last in the decision chain of the organization because the output of his/her planning process is not a directive for a lower level planning process, but results in production

1 Assistant Professor, Constr. Mgmt. and Wood Product Engrg. Department, 153 Baker Lab, State Univ. of New York, College of Environmental Science and Forestry, Syracuse, NY 13210, 315/470-6839, FAX 315/470-6879, ywkim@esf.edu

2 Ph.D. Student, Constr. Mgmt. and Wood Product Engrg. Department, 153 Baker Lab, State University of New York, College of Environmental Science and Forestry, Syracuse, NY 13210, jijang@syr.edu

(Ballard and Howell 1994). As shown in Figure 1, the Last Planner uses a "can-do" approach, which releases only workable jobs to the field in the contrast to a "should-do" approach (Howell and Ballard 1994). The shielding process called Last Planner planning is the process of "quality assignments." They (Ballard and Howell 1998) proposed that quality assignments could be achieved only when assignments meet specific quality requirements for:

- *Definition*: Are assignments specific enough that the right type and amount of materials can be collected, work can be coordinated with other trades, and it is possible to tell at the end of the week if the assignment is complete?
- *Soundness*: Are all assignments sound? For example, are all materials on hand? Is the design complete? Is the prerequisite work complete?
- *Sequence*: Are assortments selected from those that are sound in the constructability order needed by the production unit itself and in the order needed by the customer processes? Are additional, lower priority assignments identified as workable backlog, i.e., additional quality tasks available in case assignments fail or productivity exceeds expectations?
- *Size*: Are assignments sized to the productive capability of each crew or sub-crew, while still being achievable within the planning period? Does the assignment produce work for the next production unit in the size and format required?
- *Learning*: Are assignments that are not completed within the week tracked, and the reasons identified?

Making quality assignments shields production units from work flow uncertainty, enabling those units to improve their own productivity, and also to improve the productivity of those production units downstream. (Ballard and Howell 1997)

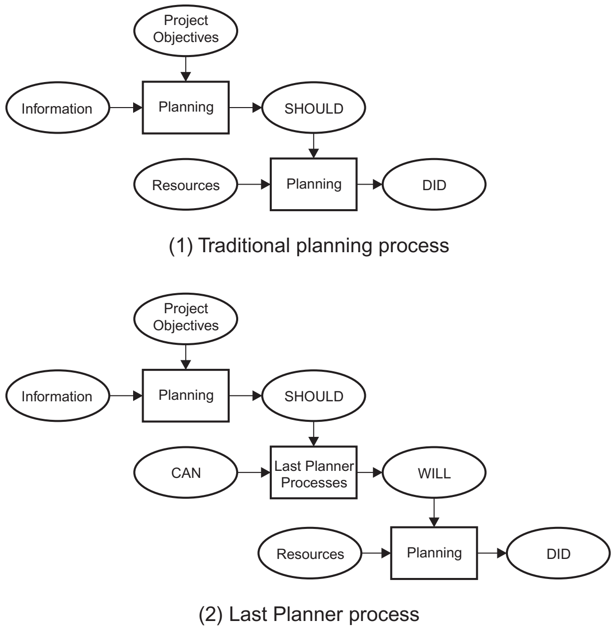

Figure 1: Planning Process (Ballard and Howell 1994)

The key performance dimension of a planning system at the crew level is its quality of output; i.e., the quality of plans produced by the Last Planner (Ballard 1994). Percent Plan Complete (PPC) is the number of planned activities completed divided by the total number of planned activities, expressed as a percentage (Ballard 1994). PPC is a measure of work flow reliability because the production plan of upstream production units is one source of information regarding work flow to downstream production units (Ballard 1999).

Table 1: Project Description

Project Title	Location	Duration of Projects	% of progress	Outline of Project	Method	Subcontract
Seoul Subway # xx	Seoul, Seoul	2003.06 ~ 2007.12	45% complete	- Tunnel : 738M - 2 Station: 527M - 3 Vent tunnels:143M	- Tunnel: NATM[3] - Station: Open Cut - Blasting	- Mechanical - Electrical - Railway - Finish
Busan Subway # xx	KyungNam, Busan	2002.05 ~ 2006.05	77% complete	- Tunnel: 1,490M - 1 Station : 225M - 2 Vent tunnels: 97M	- Tunnel: NATM - Station: Open Cut - Blasting	- Mechanical - Electrical - Railway - Finish

3 NATM, New Austrian Tunneling Method, NATM is a flexible method of tunnel excavation and support which is adaptable to varying ground conditions from hard rock to soil.(Bickel and Juesel 1999)

DESCRIPTION OF PROJECTS

The case study was conducted on two subway construction projects. The study was on tunneling and Open cut process for both projects. The outlines of the project are shown in Table 1.

The main activities and resources of projects are shown in Table 2. During the case study, the Seoul subway project was two months behind schedule, and the Busan Subway project had incurred the enmity of the people due to the blasting. Such conditions lead to unreliable work flow.

IMPLEMENTATION OF LAST PLANNER

Projects in this study use three types of plans: master schedule, phase schedule, and commitment schedule. A master schedule and phase schedule needs to be approved by a client. A master schedule is a schedule that covers from the beginning to the end of the project. A phase schedule evolved from a master schedule entails detailed activities. An approved phase schedule is evolved into three-week look-ahead schedule and a weekly work plan.

Case studies have been implemented through three phases:

1. The first phase involved calculating PPC of week work plan. Reasons for failure were identified through all three phases. However, Last Planner (i.e, the shielding process) was not implemented during this phase.
2. The shielding process through extensive constraint analysis was implemented on the course of commitment planning. In the second phase, costs were assigned to each assignment in the weekly work plan.
3. The shielding process was implemented as in the second phase. However, cost information is excluded from the weekly work plan.

1ST PHASE

A kick-off meeting was held in Nov 2004 and was co-facilitated by the authors. The participants agreed that PPC (Percentage Plan Completion) on the weekly work plan and reasons for non-completion will be traced and recorded but the Last Planner will not be implemented for a month to see how the Last Planner improves their planning system.

It is worthwhile describing the organization of the contractor. Management staffs in the project office are grouped into three departments: construction department, project control department, and administration. It is interesting that project engineers are segregated into project control department and construction department. All planning processes including weekly work scheduling are in charge of the project control department. The project control department keeps asking the construction department for schedule updates because all field engineers are in the construction department.

The planning system did not need to change during the 1st phase because projects issue the weekly work plan already. In the first phase, weekly work scheduling was performed using spreadsheets filled by the project control engineer together with the site engineer in the construction

Table 2: Description of Activities

Project Title	Main activity	Major Assignments and Resources			
		Assignments	Materials	Equipments	Labor
Seoul Subway # xx	- Earth Work : 196,097M3 - Earth Anchor : 742EA - Rock Bolt : 1,369EA - Steel Arch Rib : 861 EA - Shotcrete : 6,460 M2 - Lining : 12,150M3	- Blasting - Steel Arch Rib - Rock Bolt - Shotcrete - Wire-eash - Average weekly assignments : 114	- ANFO - Bit - Shotcrete - RockBolt - Wire-Mesh - Steel arch rib	- Excavator - Dump Truck - Crane - Drill - Fork left - Dozer	- Blasting Team - Boring Team - Shotcrete labors - Carpenters - Ironworkers
Busan Subway # xx	- Earth Work : 101,154M3 - Earth Anchor : 251EA - Rock Bolt : 3,357EA - Steel Arch Rib :1,457 EA - Shotcrete : 15,141 M2 - Lining : 27,144M3 - Water Proofing	- Blasting - Steel Arch Rib - Rock Bolt - Shotcrete - Wire-eash - Average weekly assignments : 107	- ANFO - Bit - Shotcrete - RockBolt - Wire-Mesh - Steel arch rib	- Excavator - Jumbo Drill - Dump Truck - Crane - Fork left - Dozer	- Blasting Team - Boring Team - Shotcrete labors - Carpenters - Ironworkers

department. They had a three-week look-ahead schedule.

The PPC (percent plan complete) and reasons for non-completion was tracked and published weekly. The PPC on Seoul subway project was 62% and PPC on Busan subway project was 63%. Incomplete prerequisite work and lack of materials were the major reasons for failure. Figure 2. shows the changes of PPC. Reasons for non-completion for the period are provided in Table 3.

2ND PHASE

Ad-hoc meeting and training sessions were held and co-facilitated by the authors for implementing the Last Planner in Jan 2005. The key outcomes were (1) releasing assignments that meet the five quality criteria, (2) developing and updating constraints, (3) assigning and tracing costs to each assignment. The third outcome came from top management in an attempt to bring an earned-value method to the level of operation for tighter cost/schedule control.

Subsequent to the meeting and training sessions, the production control team added a column on constraint analysis to the weekly work plan and look-ahead schedule. A weekly meeting was used to address the status of constraints, and to discuss how to resolve them. The PPC on the Seoul subway project was 79% and the PPC on the Busan subway project was 75% as shown in Figure 2. The reasons for the non-completion are also presented in Table 3.

3RD PHASE

As the Last Planner system was applied, the PPC continued to increase in value, until it reached around 85% during the 8th week. However, the PPC did not surpass the level of 85%. An ad hoc meeting was again held for overcoming the 85% limit. At the meeting, participants pointed out that the cost/schedule variance analysis at the level of operation was the obstacle. The engineers at the project control department admitted that quality assignment criteria are often sacrificed to earned-value. (i.e., they tend to release assignments with high earned-value rather than assignments that meet quality criteria). However, the project manager was concerned over the case where the PPC is high but still behind schedule and still overrun.

The solution was suggested that the impact on total float and duration can be measured and updated weekly[4]. The authors explained to the project manager that cost variance analysis at the level of operation might cause problems that impeded work flow by making earned-value a priority when deciding which assignments to release to the field, thus preventing quality assignments (Kim 2002; Kim and Ballard 2000). The outcomes of this meeting were (1) to remove cost data in weekly work plan, (2) to trace total float change every week.

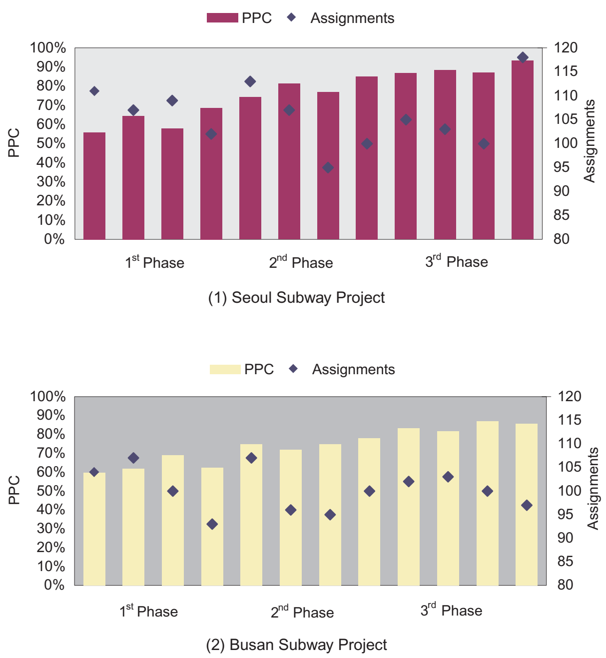

Figure 2: PPC Charts

During the third phase, the PPC climbed to 85% on the Seoul subway project and 84% on the Busan subway project. The reasons for the non-completion are presented in Table 3.

DISCUSSION

UNIT OF ASSIGNMENT

The contractor generated weekly work plan and weekly progress percentage rate prior to the case study. However, the unit of assignment for measurement was quantity of the output of operation. For example, boring crews were assigned 162 holes at a station 50k 908-914 on Sunday of week 5 in Table 4. If 140 holes were completed out of 162 holes, the contractor used to report that the progress rate was 86%. However, completing 140 holes out of 162 holes does not generate value to blasting crews. In the study, the unit of assignment is confined to the unit of hand-over to the downstream crew. For example, 140 holes is con-

4 In addition to the impact on total float, we intended to do cost analysis at higher level than the operations level. But it did not work due to the problems of data collection in the course of this study.

Table 3: Reasons for Failure

Phase		Approval		Prerequisite		Material		Equipment		Changing Plan		Weekly Total
		Seoul	Busan	Seoul	Busan	Seoul	Busan	Seoul	Busan	Seoul	Busan	
1st Phase	Week01	3	6	22	18	20	15	3	3	1	0	**91**
	Week02	7	4	12	19	17	15	2	3	0	0	**79**
	Week03	7	5	16	9	22	13	1	3	0	1	**77**
	Week04	5	7	9	13	15	14	3	1	0	0	**67**
2nd Phase	Week05	5	2	10	9	13	14	0	2	1	0	**56**
	Week06	2	3	8	11	9	10	1	3	0	0	**47**
	Week07	3	3	6	9	11	11	2	1	0	0	**46**
	Week08	1	2	8	7	5	12	1	1	0	0	**37**
3rd Phase	Week09	2	2	7	6	5	7	0	2	0	0	**31**
	Week10	2	1	4	8	5	8	1	2	0	0	**31**
	Week11	1	0	5	4	7	8	0	1	0	0	**26**
	Week12	1	2	5	6	2	4	0	2	0	0	**22**
SUM		**39**	**37**	**112**	**119**	**131**	**131**	**14**	**24**	**2**	**1**	**610**
TOTAL		**76**		**231**		**262**		**38**		**3**		

sidered one assignment if 140 holes are the unit of hand-over.

COST/SCHEDULE INTEGRATION WITH WORK FLOW MANAGEMENT

The Lean Construction Institute (1999) defined work flow as the movement of information and materials through a network of production units, each of which processes them before releasing to those downstream. Ballard and Howell (1997) showed work flow could be improved by making only quality assignments, which shields production from work flow uncertainty. The primary purpose of improving PPC through shielding process in the Last Planner is to improve work flow reliability.

Contractors often confuse work flow measurement with progress measurement. In the second phase, cost information was incorporated into the weekly work plan. It is presumably because (1) project managers preferred to have cost/progress measures on the level of operation, and (2) PPC measure was confused with progress measure. However, if budget/cost on each cost account is the main decision criterion for releasing work assignments rather than the five quality criteria, work flow can be unreliable, which results in longer durations, and higher costs than necessary, and possibly schedule and cost overruns relative to the budget (Kim and Ballard 2000). As discussed earlier, quality assignment criteria are likely to be sacrificed to earned-value.

ORGANIZATION

Work is structured and scheduled not through engineers in a construction team but through in project control team. Inefficiency exists because engineers in project control team are not very aware of site constraints such as the progress of pre-requisite works. The authors interviewed with project managers of three other general contractors in Korea. The interview revealed that all three of the contractors have the same organization structure. Sometimes the assignments are likely to be released to the site without the site engineer or foreman's confirmation. If the site engineers are to make the weekly work plan, management efficiency might be improved, not to mention the quality of assignments.

DIFFICULTY SAYING "NO"

A common habit of thought and action in the construction industry is a "Can Do" mentality (Howell and Ballard 1994). The front-end manager (i.e., Last Planner) finds it hard to reject poor assignments. This mentality is a big enemy to the improvement work flow reliability (Ballard 1999). However, the mentality seems to be reinforced in the Korean construction industry by the influence of "Confucianism."

THE ROLE OF A FOREMAN

When we asked foremen to be involved in the planning process including the weekly work plan, the foremen had a hard time in the planning and the scheduling process. Some foremen did not even understand the contents of planning docu-

Table 4: Weekly Work Plan (Seoul Subway Project, Week 5)

Station	Assignments	Unit	Amount	Week 5							Number of Assignment
				Sun	Mon	Tue	Wed	Thu	Fri	Sat	
Tunneling - Upper Level											
50K908E1 ~ 50K914E1	**NATM Tunnel Blasting**										
	Boring	Hole	972	162	162	162		162	162	162	**6**
	Blasting	Hole	972	162	162	162		162	162	162	**6**
	Mucking	M3	497.5	82.5	83	83		83	83	83	**6**
	Rock Mass Rating		1				1				**1**
	Steel Arch Rib Installation										
	Steel Arch Rib Install	EA	2			1				1	**2**
	Wire-Mesh Install										
	Wire-Mesh (1Mx3M)	EA	54	9	9	9		9	9	9	**6**
50K902E1 ~ 50K908E1	**Rock Bolt Installation**										
	Boring	Hole	140		24	23	23	23	23	24	**6**
	Rockbolt Install	Hole	140		24	23	23	23	23	24	**6**
	Shotcrete										
	Primary Shotcrete	M2	162	27	27	27	27	27	27		**6**
	Secondary Shotcrete	M2	162		27	27	27	27	27	27	**6**
	Tertiary Shotcrete	M3	162		27	27	27	27	27	27	**6**
Tunneling - Lower Level											
50K868E1 ~ 50K874S1	**NATM Tunnel Blasting**										
	Boring	Hole	1080	180	180	180	180		180	180	**6**
	Blasting	Hole	1080	180	180	180	180		180	180	**6**
	Mucking	M3	540	90	90	90	90		90	90	**6**
	Steel Arch Rib Install										
	Steel Arch Rib	EA	4	2			2				**2**
50K862E1 ~ 50K868S1	**Shotcrete**										
	Primary Shotcrete	M2	146	25	24	24	25		24	24	**6**
	Secondary Shotcrete	M2	146	25	24	24	25		24	24	**6**
	Tertiary Shotcrete	M2	146	25	24	24	25		24	24	**6**
50K856E1 ~ 50K862S1	**Appurtenant work**										
	Weep/Drain	M	6	1	1	1	1		1	1	**6**
	Waterproofing	M	6	1	1	1	1		1	1	**6**
	Electric work	EA	6	1	1	1	1		1	1	**6**
Total Number of Assignments				**15**	**18**	**19**	**16**	**9**	**18**	**18**	**113**

ments. Traditionally, the role of the foreman is limited to dispatching directives to the crew and supervising the work underway. In this study, foremen were not involved in the planning process, and not trained for the planning process. However, the role of the foreman *should* change; it *should* engage in forming work flow by actively involving the Last Planner system.

CONCLUSION AND MOVING FORWARD

Through pilot project, this paper is meant to initiate a discussion about the potentials and barriers to implementing the Last Planner as a production control tool in a heavy civil project in Korea.

The pilot study showed that the Last Planner improved work flow reliability (i.e., improving

PPC) in tunneling projects. However, the study indicated several barriers. Four actions have been proposed to improve PPC and the work flow reliability:

- Removing cost information from the weekly work plans,
- Coupling plan-generating teams with field engineers and foremen,
- Overcoming the mentality of saying "Yes" to the boss all of the time,
- Training foremen to plan.

The planning team worked with field engineers and foremen in the pilot study as a result of our consultation. However, we recommended that the PPC and the work flow reliability be improved if the task of commitment scheduling moves to the construction team.

Practitioners who are willing to implement the Last Planner in Korea need to come up with solutions for the above-mentioned barriers. We expect other researchers and practitioners to implement the implementation of lean construction in Korea, and to disseminate their findings, and also to comment on our findings.

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