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Last Planner System and the Performance of Construction Projects

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Abstract. Scheduling serves as one of the critical aspects in the construction business and industrial activity. The last planner system has been used as one of the methods on the construction project. By applying the last planner system as a construction control method, the project can run on schedule, the cost does not exceed planning, and the quality of work on a project can be guaranteed. This research seeks a correlation between the last planner system and construction project performance. This research using a questionnaire method to find the project last planner system implementation and project performance. The data that answered by respondents are analyzed using SPSS program with Spearman ranking to find a correlation between the last planner system and construction project performance. The results show that there are eight very strong and significant relations between the last planner system implementation and project performance.

Keywords: last planner system, key performance index, Spearman ranking.

1. Introduction

Scheduling is an essential aspect of the cycle of business activities and the construction industry. Contractors who do not have an understanding of the components of work items and scheduling will influence the performance of a project. Proper workforce scheduling and setting determine the performance of a project. Today many construction companies have implemented the last planner system (LPS) in the planning stage due to the strong construction industry. Last planner system is a method that applies the phases of plan, do, check and action. The LPS is a production planning system designed to produce predictable and easy-to-understand workflows in planning, design and construction phases. The application of LPS to contractors is generally made using percent planned completion (PPC) parameters. By applying the LPS by careful planning, proper monitoring, and proper supervision, the project can run on

schedule, the cost does not exceed planning, and the quality of work on the project can be guaranteed.The LPS is an effective tool to improve the reliability of planning in projects [1].

To determine a project can be successful or not, the project measured by the performance of the project or key performance index. Insufficient knowledge of work plans and methods will have an impact on the field team because the effects of this are in the form of cost overruns or project delays. The achievement indexes are subjective in value so that the project can be said to be a good, medium or wicked project. Key performance indicator (KPI) measures the project performance index. The application of the LPS method that is good by the contractor will have a significant impact on the project performance. LPS is a method for managing the planning and production phases of the construction work cycle.

Last Planner System is one of the methods to manage control and production phase of a construction project. Project performance generally measures cost, time and quality. LPS make significant improvements in the performance of construction projects worldwide [7]. Performance improvement impacts between 7% to 48% were reported by companies that participated in the implementation program [1].

This research examined the influence of implementing the LPS on project performance; how big or significant the influence is so that it becomes a reference for the contractor as well as for the owner to know that management makes a good planning system in a project so that the project can work well.

Research scope was limited to high rise buildings using facts found on projects carried out by contractor companies A.

2. Research Methods

This research began by studying some literature on the application of LPS and KPI in construction projects.

This research was conducted in five construction projects from a construction company operating in Surabaya. To avoid answer bias, the project selected was the one which has been running for at least three months and or the project which has been completed. All projects selected were for high-rise buildings. The project under the research was a project with the application of the LPS method. This research used a questionnaire and case study method. A total of 62 people participated in the questionnaire to determine the application of LPS and KPI projects under study. Those 62 people are those who have applied and understood the LPS method in their construction project.

The data answered by respondents would be analyzed using the SPSS program using the Spearman Ranking method to find the relationship between the application of LPS and the performance of construction projects. After that, it was continued by collecting data based on the implementation of LPS on the project.

Several interviews with respondents then strengthened this research. Interviews were conducted to find some facts about the relationship between LPS and KPI management practices. In the end, the case study analysis will illustrate all project implementation in the LPS and construction project performance.

In the end, the case study analyzes will describe all projects implementation on LPS and construction project performance.

2.1. Data Analysis

The data collected were tested for the validity and reliability. The data were tested using the SPSS program.

After the data were collected, the data were analyzed to find the mean for each application of LPS and KPI median to find the project with the best application of LPS and the best construction project performance.

The raw data that collected from the questionnaire will be ranking and applied on Spearman correlation using SPSS program. The ranking was assigned, ranging from 1 as the best performance up to 5 as the worst performance. Spearman's r is the correlation coefficient on the ranked data and varies from 0 for no correlation 1 for full correlation. Only strong (0.6<=r<0.8) and very strong (r=>0.8) correlation value were considered relevant [8]. The o value, or the probability value, is a statistical measure that helps determine whether correlation hypotheses are correct or not. Null correlation hypotheses are discarded when p-value is equal to 0.05 or less.

Castillo defines there are 15 LPS management practices on the field [7]. Table 1 is explained by the use of 15 LPS management practices and their abbreviations. A scale from zero for not implemented to one or entirely implemented was associated to this list.

Table 1. LPS Implementation

No	Code	LPS Management Practice
1	L1	Formalization of the planning and control process
2	L2	Standardization of short-term, planning meetings
3	L3	Use of visual devices to disseminate information
4	L4	Corrective actions based on the cause non completions of plans
5	L5	Critical analysis of data
6	L6	Correct definition of work packages
7	L7	Systematic update of the master plan
8	L8	Standardization of the medium-term planning
9	L9	Inclusion of only work packages without constraints in short-term plans
10	L10	Participation of crew representatives in decision making in short-term planning meetings
11	L11	Planning and controlling and physical flows
12	L12	Use of indicator to assess schedule accomplishments
13	L13	Systematic removal of constraints
14	L14	Use of an easy to understand, transparent master plan
15	L15	Scheduling a backlog of tasks

Castillo defines there is 9 KPI median [7]. Table 2 is explained about 10 KPI median and their abbreviations. A scale from zero for the worst performance to five for the best performance on the construction project.

Table 2. KPI

No	Code	KPI
1	K1	Contract bid changes
2	K2_1	Concrete productivity
3	K2_2	Rebar productivity
4	K3	Quality
5	K4	Cost deviation
6	K5	Constraint release
7	K6	Planning effectiveness
8	K7	Schedule deviation
9	K8	Accident frequency index
10	K9	Accident gravity index

3. Results and Discussions

3.1. General Data

This research will retrieve data from five projects. Project A, project B, project C, project D, project E. The five projects are high-rise buildings. The questionnaireswere distributed to

contractors in April 2018. During the survey, the author had succeeded in getting 62 questionnaires and respondents.

The data collected were the answers to the questionnaire from respondents who had met the criteria and were willing to answer questionnaire questions according to the respondent's personal experience.

After observing the data on the respondents, the data were tested first to prove that the instrument in the form of questionnaires used in this research was suitable for use. The test was carried out in 2 stages; Validity and Reliability tests

3.2. Project Ranking based on LPS Implementation

Based on the 15 LPS management practices with the LPS implementation method in the construction project, project A was the project with the best LPS management practices, followed by project E, project D, project B, and project C.

In this research, one application of LPS has always been a bad value on five projects. Thatapplication of LPSwas critical data analysis. Based on the study, the lack of staff who understood the use of LPS in five projects influenced the assessment of the application of LPS.

Based on the study, LPS implementation could be different between project cause on:

1. Project difficulty level.
2. Plan misinformation on the project.
3. Lack of integration between planning and controlling scheme.
4. Lack of staff stress management.

It could be seen in Table 3, about project ranking based on LPS management practices.

Table 3. Project Ranking based on LPS Management Practices

Projects		**LPS Management Practices**														
		L1	**L2**	**L3**	**L4**	**L5**	**L6**	**L7**	**L8**	**L9**	**L10**	**L11**	**L12**	**L13**	**L14**	**L15**
A	Rank	2	1	1	2	2	1	2	1	2	2	1	2.5	2	4	5
B	Rank	3	4	4	1	1	4	3	3	4	4	4	2.5	3	2	1
C	Rank	4	5	5	3.5	3.5	5	5	4.5	5	5	5	4	5	5	3
D	Rank	1	3	3	4	4	3	1	4.5	3	3	3	1	1	3	4
E	Rank	1	2	2	3.5	3.5	2	4	2	1	1	2	3	4	1	2

Based on the study, there are many steps to increase LPS implementation on projects, such as:

1. Training
2. Proactive interaction with contractor upper management and project organization
3. Collaboration among companies and the constant search for new ways to improve the implementation process.

3.3. Project Ranking based on Project Performance

Based on the KPI's assessment on these 10 points, the conclusion by the respondent is that project B has the highest project performance, followed by project E, project D, project A, and project C.

It could be seen in Table 4, about project ranking based on construction project performance.

Table 4. Project Ranking based on Construction Project Performances.

Projects		KPI									
		K1	**K2_1**	**K2_2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**
A	Rank	3	3	2.5	1	5	5	4	4	4	4.5
B	Rank	1	4	1	3	2	2	5	1	1	1
C	Rank	5	5	3	5	4	4	3	5	3	4.5
D	Rank	4	2	4	2	3	3	2	3	2.5	3
E	Rank	2	1	2.5	4	1	1	1	2	2.5	2

Thus, differences in project performance were measured cause by owner decision, the location of projects, change of order.

3.4. The relationship between Application of LPS and Project Performance Assessment through KPI

After analyzing the mean and ranking the project rankings, the research was continued by looking for the relationship between LPS and KPI.

A simple linear correlation was used to pair each management practice score and the median of each project's KPIs. The result is shown in Table 3.

Table 5. The Relation between LPS Management Practices and KPI

LPS management practices	KPI	Spearman r	p-valor
Corrective actions based on the cause non-completion plan	Contract bid changes	0.949	0.014
Critical data analysis	Rebar productivity	0.918	0.028
Systematic update of the master plan	Quality index	0.900	0.037
Planning and controlling physical flow	Concrete productivity	0.900	0.037
Systematic removal of constraints	Quality index	0.900	0.037
Use of an easy to understand, transparent master plan	Cost deviation	0.900	0.037
Use of an easy to understand, transparent master plan	Constraint release	0.900	0.037
Use of an easy to understand, transparent master plan	Schedule deviation	0.900	0.037

In Table 5, it has clear that corrective actions based on the cause non-completion plan has stronger relation to contract bid changes. Based on research, on project A contract bid changes due to flawed or incomplete designs, demand changes, unknown field conditions, unclear contract language, and acceleration commands [9].

In project A has a bad value on the application of LPS in scheduling backlog assignments and critical data analysis, project A has a bad value on KPI in a schedule deviation.

Two project performance factors are influenced based on the owner's decision rather than the method of applying LPS from a contractor like:

1. Contract bid changes
2. Schedule deviation

Based on the research, to improve the application of LPS to the project, several actions that must be carried out are:

1. Staff training on LPS methods.
2. Organize the composition of new staff and old staff so that they become balanced in a scientific and spirit-based manner in construction projects.
3. Internal audit is needed to check and re-evaluate the application of LPS in construction projects on a regular basis.

4. Conclusions

From the results of the application of the LPS, it can be concluded that the project with the best LPS method application is in Project A, followed by Project E, Project D, Project B, and Project C.

From the results of the project performance assessment research measured through KPI, it can be concluded that the best project performance project is in Project B, followed by Project E, Project D, Project A, and Project C.

The results of the research conclude that there is a relationship between the application of LPS and project performance (KPI) through the SPSS program. Eight significant and very strong relationships occur between the application of the LPS and the assessment of project performance through KPI. These factors should be taken in future research.

There are differences in the average application of LPS for each project due to several things:

1. Level of project difficulty.
2. The failure to deliver information between teams.
3. Less integration between planning and control schemes.
4. The instability stress of staff spirit.

To improve the application of LPS can be done by:

1. Staff training related to LPS.
2. Organizing the composition of new staff and old staff so that they are not biased.
3. The need for self-correction or from an audit is held to improve the application of the LPS.

Further research is needed on several supporting factors and inhibiting factor for the implementation of the last planner system on the performance of construction projects. It is recommended to take many respondents from various construction companies.

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