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Research paper

Key factors of success in the application of last planner system in construction work

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Abstract

This study aims to identify what factors are the key to the successful implementation of the Last Planner System in construction work based on existing journals to be applied in the construction environment and determine the priority weight / key factors of success from the questionnaire results from experts with the Analytic method Hierarchy Process. The method used in this study uses the Analytic Hierarchy Process to find priority weights and software uses Expert Choice. From the results of the analysis obtained Key Success Factors in construction work, namely as many as 10 criteria where stakeholder criteria with the highest priority weight with a global weight of 0.2279 which have a value of consistency ratio below 0.1 or 10%, ie 0.08 or 8%, then an evaluation of the comparison pairing between criteria is consistent and as many as 24 sub-criteria where the sub-criteria of stakeholder support for the implementation of LPS with the highest priority weighting with a global weight of 0.1812 which has a consistency ratio below 0.1 or 10% ie 0.07 or 7%, then an assessment of pairwise comparisons between sub criteria are consistent.

Keywords: *Key Success Factors; Last Planner System; Analytic Hierarchy Process.*

1. Introduction

One of the problems that often recurs in construction is tardiness. The construction world often experiences delays that occur repeatedly with cost overruns, especially for developing countries [1]. Indonesia as one of the developing countries where development is going on a massive scale, requires an anticipation to overcome this. Previous studies on delays in various countries revealed that poor project management was one of the main reasons reported for construction delays.

Since the early 1990s, the application of Lean Construction has been practiced as a way to manage construction more efficiently and effectively. Among its main objectives are improving planning efficiency and reliability, reducing waste and increasing productivity [2]. Various Lean Construction techniques (lean construction) have been applied by many construction companies throughout the world aiming to improve their project management practices by eliminating waste, increasing productivity, and maximizing value.

The best known technique of Lean Construction is the Last Planner System (LPS) which has been demonstrated over the past decade as a very useful tool for the management of the construction process and the ongoing monitoring of planning efficiency [3].

LPS has not been widely used and has good potential because it is part of the lean construction component in which in planning all parties can be directly involved and coordinated so that the planned work can be well controlled in its implementation. LPS has been proven effective in achieving and maintaining work plans above 70%, [4].

The goal of the Last Planner System according to Ballard (1997) is to increase productivity by removing workflow obstacles. One of the main advantages is that it replaces optimistic planning with realistic planning by assessing the performance of past planners based on their ability to achieve their commitments [5].

2. Key factors for project success

Successful projects are projects that have far better results than estimates that are usually observed in terms of cost, schedule, quality, safety and satisfaction of the parties involved described a successful project as a project that was completed as expected, where the project had taken into account all project requirements, had sufficient resources to meet the needs in a timely manner [6]. The definition of project success has differences between researchers, this is due to the view of success depending on the perspective chosen [7].

The definition of success factors, first published or published by D. Ronald Daniel of McKinsey & Company in 1961. Critical Success Factor (CSF) is a management term for an element that is necessary for an organization or project to achieve its mission. Alternative terms are Key Result Areas (KRA) and Key Success Factors (KSF). Critical Success Factor (critical success factor) is a management terminology for an element / element / activity / factor needed by an organization or project to achieve its targets. Other alternatives to this terminology are the Key Result Area (KRA), the key area of success and the key success factor (KSF) key to success.

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Lim and Mohamed (1999) classify the perspective of project success into two categories: macro and micro viewpoints. Macro perspective on project success starts from the conceptual stage to the operational or product has been used. While the micro viewpoint is the success of the project seen at the construction stage and usually this involves the parties involved in the construction phase. At the construction stage it can be seen how effective the project management function is in achieving its objectives [8].

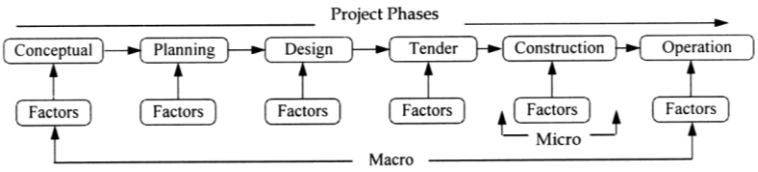


Fig. 1: Macro and Micro Views in the Lifecycle Project.

Sources: Lim and Mohamed, 2004

2.1. Lean construction

2.1.1. History of lean construction

The development of Lauri Koskela's theory in 1992 made a challenge for the Construction Management community to consider the shortcomings of the time, cost and quality paradigms of a product. People who have examined a new paradigm [9].
Many activities are found that are not needed during the construction process, namely activities that require extra time and effort without adding value to the project owner [10]. Since the early stages of a construction project, the construction manager should have involved all the factors that might have a negative effect on the construction process, namely waste which includes delays, costs, quality, lack of construction safety, rework, unnecessary movements, long distance, management selection wrong, inadequate method or tool and constructability [11]. Meanwhile, according to data from the Construction Industry Board, waste includes technical or non-technical errors, working out of sequence, repetitive activities and movements, delays, inputs and products or services that are not in accordance with the requirements of the project owner.

2.2. Last planner system (LPS)

The Last Planner System was officially introduced in the construction industry more than 25 years ago. The LPS developed by Ballard and Howell in 1992 focused on reducing uncertainty in workflows that were ignored in traditional project management [12]. Uncertainty or variability in workflows have been identified as contributing factors to poor performance of construction projects [13]. However, LPS is an integrated and comprehensive approach that intends to increase the predictability and reliability of construction activities planned at the construction implementation stage [14].
It should be noted that the application is not limited to the construction phase, because it is also effective at the design stage. Previous studies have reported LPS implementation in building construction, civil engineering construction, road construction and infrastructure projects, including ship building and mining [15].
This Last Planner System is an attempt to review what has been planned before it is executed by the most competent personnel for the work planned and will carry out the work. The personnel will then be the Last Planner System. With the existence of this system, there will be an assessment of existing field conditions both resources and locations that will provide input for evaluating existing plans before they are implemented. The results of the correction will then be carried out in the field. With the Last Planner System, the push principle (where fieldworkers have to carry out what is planned) that is usually done will be replaced with a pull system in accordance with the concept of lean construction.
In this system, there are performance indicators that are used to measure the extent to which work flow can be achieved properly, namely Percent Planned Completed (PPC). PPC is a measure of the extent to which planned flow can run. Last Planner System will succeed if the PPC is high. To support this system there are additional planning details as a tool to be able to detect the reliability of the plan and the possibility of expected flow in the field. Weekly detailed schedule, monthly schedule (look a head plan), and main schedule (master schedule) become a dynamic and important combination in this syste The Last Planner System was officially introduced in the construction industry more than 25 years ago. The LPS developed by Ballard and Howell in 1992 focused on reducing uncertainty in workflows that were ignored in traditional project management [16]. Uncertainty or variability in workflows have been identified as contributing factors to poor performance of construction projects [17]. However, LPS is an integrated and comprehensive approach that intends to increase the predictability and reliability of construction activities planned at the construction implementation stage [18].
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Sumber: Ballard, 2000
Gambar 1: Tradisional (Push) Planning System

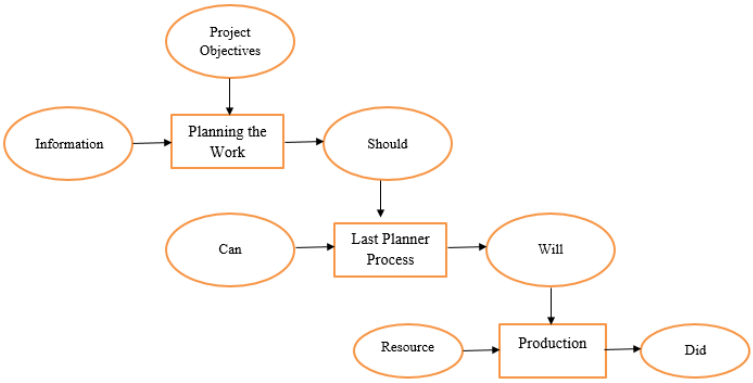


Fig. 2: Last Planner: A Pull System.

Source: Ballard, 2000.

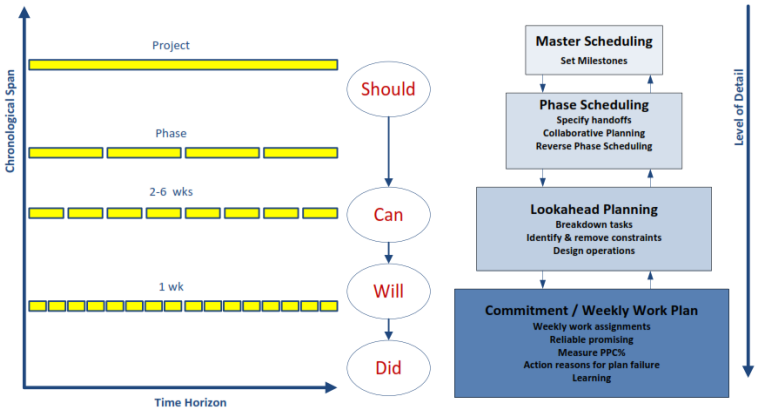


Fig. 3: Illustration of Display LPS Planning (Planning Stage / Level).

2.3. Workflow control LPS

In this system, there are performance indicators that are used to measure the extent to which work flow can be achieved properly, while the Last Planner System workflow control is:

2.3.1. Master plan

Master plan is the overall project schedule, with milestones, which are usually generated for use in work packages. Reverse Phase Scheduling (RPS) will be produced based on the Master schedule.

2.3.2. Phase planning and pull planning

The function of the planning phase is to produce a detailed schedule that includes each phase of the project as a foundation in determining further planning, structural framework, and finishing. In making this planning phase, it is more profitable to work with the team [19]. The works in the planning phase will be developed first into assignments (tasks) in accordance with the desired level of detail. In this process a pull planning will be made simultaneously where the project team members determine how the project work is done to achieve results on a predetermined schedule / milestone. [20]. The pull planning process is described as follows:

1) All team members responsible for doing assignments will participate in making the Phase Pull Schedule (PPS).
2) PPS is made together with related parties (teams) to set the context, determine the schedule, look for execution strategies, identify assignments and set the team to work. All assignments in PPS must be defined and accepted by the owner.
3) PPS is completed when team members agree on the assignment criteria given between the activities, sequence, and estimated time of work, as well as the resources (material, labor, and cost) to complete the assignment. [21].

2.3.3. Look a head schedule

Serpel (1995) shows that a tool to control work flow is a look a head schedule. Look a head shows what kind of work should be done in the future. In order to look a head, week 1 is next week, a week after the WWP meeting. The number of weeks of look a head varies. For the design process, the look a head frame can be 3 to 12 weeks . All look a head times and schedules are estimated based on the results of the RPS, and the constraints indicated in order to solve the problem before actual production occurs. Look a head distributed to all the last planners at the WWP meeting. The essence of the look a head process is a schedule that contains jobs that have the potential to be done. Some assignments included in the look a head planning are subject to constraints analysis to be actually carried out. Lean look a head planning is a process to reduce uncertainty to achieve freedom from obstacles that may occur [22].

2.3.4. Constraints analysis

Constraints analysis is a constraint that can be in the form of contracts, designs, submittals, materials, prerequisite work, workspaces, equipment, workers and others. Other obstacles may be in the form of licensing, supervision, approval, and so on depending on the char-

acteristics of the project concerned. To be able to do constraints analysis, requires collaboration with all parties involved. If this constraints analysis is not carried out it will tend to be too reactive if something suddenly happens in the project implementation [23].

2.3.5. Shielding production

By making quality assignments or shielding production, it will be able to protect production units from uncertain work flow, making these units to increase productivity, and also to increase the productivity of subsequent production units so that can help to reduce the duration of the project. Ballard and Howell (1998) have proven that high-quality assignments can be obtained by filtering before entering into the weekly working plan (WWP). The following are the criteria for quality assignments.

1) Definition; assignments must be specific enough, which can be explained and coordinated with other parties, and allow to be measured at the end of the week whether the assignment can be completed or not.
2) Soundness; assignment must be possible to do.
3) Sequence; the assignment selected must have the correct order conditions. Here assignments that have the potential to be worked on can be entered into the workable backlog.
4) Size; assignment must have a size and target in accordance with the production capacity of each party.
5) Learning; assignments that are not completed must be monitored and identified the causes of the incomplete work, with the aim of improvement and as a learning process to develop reliable planning in the next period. (Ballard and Howell, 1998).

2.3.6. Weekly work plan (WWP)

Should, can, will are key terms in WWP. To stabilize the work environment with planning starts with learning to make and keep commitments. The person or group that is given the responsibility is expected to be able to make a commitment (WILL) to do what must be done (SHOULD) but the priority work is work that must be done (CAN). In practice, work that can be done (CAN) is included in the workable backlog and that cannot be carried out, the time of the work will be delayed (Patel, 2011).

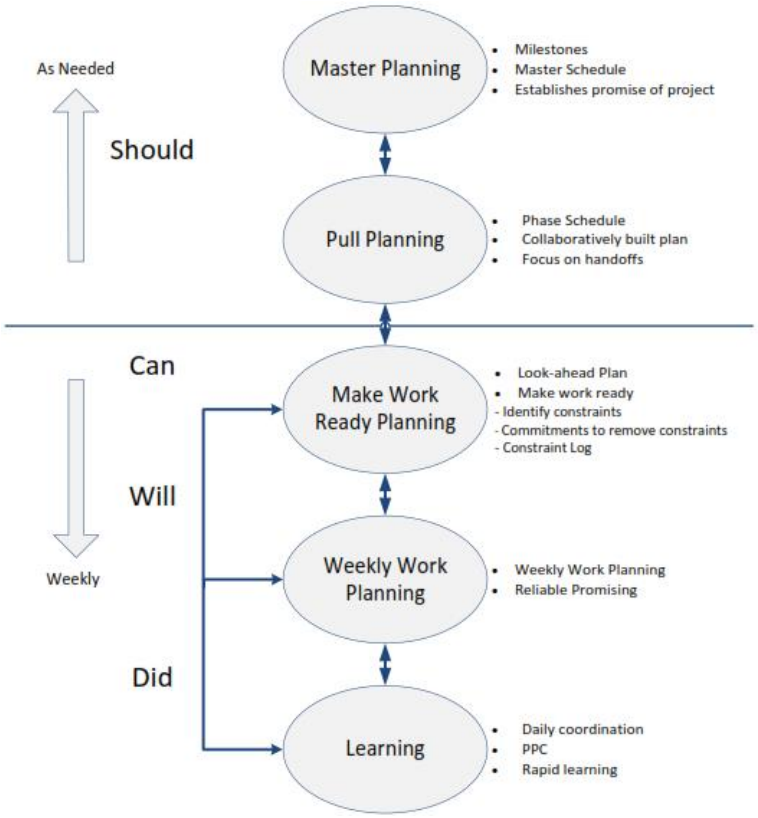


Fig. 4: Illustration of Should - Can - Will - Did Planning to Create and Maintain Workflow.

Source: Ballard, 2000

The Weekly Work Plan (WWP) is produced based on Look a head, the actual schedule and field conditions before the weekly meeting. With this plan, the workforce of each job will be adjusted to the needs. WWP meetings include weekly schedules, safety issues, quality, material, labor, construction methods, and any problems that occur in the field. This encourages two-way communication and team planning to share information about the project in an efficient and accurate way.

3. Research method

The study was conducted to determine the Key Success Factors (FKS) of the Last Planner System in construction projects. The research design that will be used is a qualitative research method. The multi-criteria type of decision-making analysis method used is the Analytic Hierarchy Process (AHP) method which was popularized by Saaty 1970.

4. Results and discussion

Comparison of this paired data to get the level of relative importance or priority over each of the Criteria for Evaluating the Key Factors of the Last Planner System's Success in Construction Work. The assessment rates of the four expert respondents involved in this study were averaged with a geometric mean with the aim of obtaining a single value from the four respondents.

1) Calculation of geometric mean (geomean) for comparison between criteria using the formula:

$$G = \sqrt[n]{X1 . X2 . X3. X4}$$

Information;
G = Geometric mean
X 1-4= Rating of expert respondents 1 to 4
n= Number of expert respondents
Complete results from the calculation of geometric averages for each criterion can be seen in Table 1 below.

Table 1: Geometric Average Value of Pairwise Comparisons Between Criteria Using Expert Choice

	Top Management Support	Commitment	Communication	Stakeholders	Human Resources	Design	Conduct Training	External	Managing Resistance	Motivation
Top Management Support		3,0	3,88	3,0	4,41	4,41	3,41	3,0	4,41	4,41
Commitment			4,41	2,71	3,0	4,41	2,71	2,71	3,41	4,21
Communication				3,41	2,44	2,0	2,0	2,0	2,0	2,0
Stakeholders					3,0	3,0	3,0	3,0	3,0	3,0
Human Resources						3,0	2,0	2,0	3,0	2,0
Design							2,21	2,71	2,0	2,21
Conduct Training								2,0	3,09	2,71
External									3,0	3,0
Managing Resistance										2,0
Motivation	Incon: 0,08									

With a consistency index (CR) of 0.08 or 8%, which is less than 0.1 or 10%, the assessment of the pairwise comparisons above is consistent.

4.1. Pairwise comparison between sub criteria

Comparison of paired data is to get the level of relative importance or priority for each Sub Criteria Criteria for the Key Success Factors of the Last Planner System in Construction Work. Complete results from the calculation of geometric averages for each sub-criterion can be seen in the Table below.

1) Calculation of geometric mean (geomean) for comparison between sub criteria using the formula:

$$G = \sqrt[n]{X1 . X2 . X3. X4}$$

Information;
G = Geometric mean
X 1-4= Rating of expert respondents 1 to 4
n= Number of expert respondents

4.2. Sub criteria of top management support

Table 2: Geometric Average Sub Criteria of Top Management Support Using Expert Choice

	Towards LPS Implementation	Control of the LPS Method	Providing Facilities for the LPS Team
Towards LPS Implementation		4,41	3,88
Control of the LPS Method			(2,0)
Providing Facilities for the LPS Team	Incon: 0,03		

From table 2 above shows the tendency of expert respondents:

1) Sub criteria for LPS implementation are more important than control criteria for LPS method by 4.41 and more important than sub criteria for providing facilities for the LPS team by 3.88.
2) Sub criteria to provide facilities for the LPS team are more important than the control sub criteria for the LPS method of (2.0) or ½ = 0.5.

With a consistency index (CR) of 0.03 or 3%, which is less than 0.1 or 10%, the assessment of the pairwise comparisons above is consistent.

4.3. Sub criteria of commitment

Table 3: Geometric Average Sub Criteria of Commitment Using Expert Choice

	Proactive Role of Each Division of Work	Time As Planned	Quality in Accordance
Proactive Role of Each Division of Work		3,41	3,0
Time As Planned			(2,0)
Quality in Accordance	Incon: 0,03		

From table 3 above shows the tendency of expert respondents:

1) The proactive role sub-criterion for each division of work is more important than the planned sub-time criteria of 3.41 and more important than the quality sub-criterion in accordance with the stipulated 3.0
2) Sub criteria of quality according to predetermined are more important than the sub time criteria as planned as (2.0) or ½ = 0.5.

With a consistency index (CR) of 0.03 or 3%, which is less than 0.1 or 10%, the assessment of the pairwise comparisons above is consistent.

4.4. Sub criteria of communication

Table 4: Geometric Average Sub Criteria of Communication Using Expert Choice

	Coordination Between Workers	Daily Meeting
Coordination Between Workers		3,0
Daily Meeting	Incon: 0,00	

From table 4 above shows the tendency of expert respondents:

1) Sub-criteria of coordination between workers are more important than daily meeting sub-criteria of 3.0.

With a consistency index (CR) of 0.0000 or 0% ie less than 0.1 or 10%, the assessment of the pairwise comparisons above is consistent.

4.5. Sub criteria of stakeholders

Table 5: Geometric Average Sub Criteria of Stakeholders Using Expert Choice from Table 5 Above Shows the Tendency of Expert Respondents

	Stakeholder Support for LPS Implementation	Good Relationship with Stakeholders
Stakeholder Support for LPS Implementation		3,88
Good Relationship with Stakeholders	Incon: 0,00	

1) Sub-criteria of stakeholder support for the implementation of IDIC is more important than sub-criteria of good relations with stakeholders of 3.88.

With a consistency index (CR) of 0.0000 or 0% is less than 0.1 or 10%, the assessment of the pairwise comparisons above is consistent.

4.6. Sub criteria of human resources

Table 6: Geometric Average Sub Criteria of Human Resources Using Expert Choice

	Has Been Involved In Implementing LPS	Has a Leadership Spirit and Strong Teamwork
Has Been Involved In Implementing LPS		3,88
Has a Leadership Spirit and Strong Teamwork	Incon: 0,00	

From table 6 above shows the tendency of expert respondents:

1) Sub criteria that have been involved in the application of LPS are more important than sub criteria having a strong leadership and teamwork spirit of 3.88.

With a consistency index (CR) of 0.0000 or 0% ie less than 0.1 or 10%, the assessment of the pairwise comparisons above is consistent.

4.7. Sub criteria of design

Table 7: Geometric Average Sub Criteria of Design Using Expert Choice

	Mature and Structured Planning	Clear Work Pictures	Clear specifications
Mature and Structured Planning		4,41	2,71
Clear Work Pictures			(2,45)
Clear specifications	Incon: 0,02		

From table 7 above shows the tendency of expert respondents:

1) A well-planned and structured sub-criterion is more important than a clear working draw sub-criterion of 4.41 and more important than a clear specification sub-criterion of 2.71
2) Sub-criteria of specification are clearly more important than sub-criteria of clear working drawings of (2.45) or '1 / 2.45 = 0.4081

With a consistency index (CR) of 0.02 or 2% which is less than 0.1 or 10%, the assessment of the pairwise comparisons above is consistent.

4.8. Sub criteria of conducting training

Table 8: Geometric Average Sub Criteria of Conducting Training Using Expert Choice

	LPS training	Increase Job Productivity
LPS training		3,88
Increase Job Productivity	Incon: 0,00	

From table 8 above shows the tendency of expert respondents:

1) Sub-criteria of LPS training are more important than sub-criteria of increasing work productivity by 3.88.

With a consistency index (CR) of 0.0000 or 0% ie less than 0.1 or 10%, the assessment of the pairwise comparisons above is consistent

4.9. Sub criteria from external

Table 9: Geometric Average Sub Criteria from External Using Expert Choice

	Climate conditions	Safety	Available Space
Climate conditions		3,88	2,71
Safety			(2,0)
Available Space	Incon: 0,01		

From table 9 above shows the tendency of expert respondents:

1) Sub-criteria of climate conditions are more important than the safety sub-criteria of 3.88 and more important than the sub-criteria of available space / space of 2.71.
2) Sub criteria of available space are more important than safety sub criteria of (2.0) or 1/2 = 0.5

With a consistency index (CR) of 0.01 or 1%, which is less than 0.1 or 10%, the assessment of the pairwise comparisons above is consistent.

4.10. Sub criteria of managing resistance

Table 10: Geometric Average Sub Criteria of Managing Resistance Using Expert Choice

	Ready to Make Changes	Build Trust And Positive Relationships
Ready to Make Changes		(3,0)
Build Trust And Positive Relationships	Incon: 0,00	

From table 10 above shows the tendency of expert respondents:

1) Sub criteria of building trust and positive relationships are more important than sub criteria ready to make changes of (3.0) or 1/3 = 0.3333 With a consistency index (CR) of 0.0000 or 0% ie less than 0.1 or 10%, the assessment of the pairwise comparisons above is consistent.

4.11. Sub criteria of motivation

Table 11: Geometric Average Sub Criteria of Motivation Using Expert Choice

	Give bonuses and additional salaries	Recognition of the Work Results
Give bonuses and additional salaries		(3,0)
Recognition of the Work Results	Incon: 0,00	

From table 11 above shows the tendency of expert respondents:

1) Sub criteria for recognition of work results are more important than sub criteria giving bonuses and additional salaries of (3.0) or 1/3 = 0.3333

With a consistency index (CR) of 0.0000 or 0% ie less than 0.1 or 10%, the assessment of the pairwise comparisons above is consistent.

4.12. Consistency ratio

AHP tolerates a consistency level of 10% or less. If more than 10%, then the respondent is considered inconsistent in answering questions and allowed to make improvements to the assessment given

Value of Conistency Ratio of all pairwise comparisons can be seen in table 4.13. The table shows the consistency ratio value of each pairwise comparison below 0.1 or 10%, so the relative importance preference value is consistent.

Table 4.13: Consistency Ratio Comparative Value between Assessment Criteria Key Success Factors Last Planner System in Construction Work

No	Pairwise Comparison Between Criteria	the value of the Consistency Ratio
1	a) Top Management Support b) Comitment c) Comunication d) Stakeholders e) Human Resources f) Design g) Conduct Training h) External i) Managing Resistance j) Motivation	0,08

Table 4.14: Consistency Ratio Comparative Value between Sub Criteria Assessment Key Success Factors Last Planner System in Construction Work

No		Pairwise Comparison Between Sub Criteria	Criteria Consistency Ratio
1	A.	B. Top Management Support Sub Criteria: - Towards LPS Implementation - Control of the LPS Method - Providing Facilities for the 0.03 LPS Team	0,03
2	C.	D. Commitment Sub Criteria: - Proactive Role of Each Division of Work - Time As Planned - Quality in Accordance with 0.03	0,03
3	E.	F. Sub Criteria for Communication: - Coordination Between Workers - Daily Meeting	0,0000
4	G.	H. Sub Stakeholder Criteria: - Stakeholder Support for LPS Implementation - Good Relationship with Stakeholders	0,0000
5	I.	J. Sub Criteria Human Resources: - Has Been Involved In Implementing LPS	0,0000

		- Has a Leadership Spirit and Strong Teamwork	
		L. Design Criteria Sub:	
6	K.	- Mature and Structured Planning - Clear Work Pictures - Clear specifications	0,02
		N. Sub Criteria for Conducting Training:	
7	M.	- LPS training - Increase Job Productivity	0,0000
		II. External Performing Sub Criteria:	
8	I.	- Climate conditions - Safety - Available Space	0,01
		IV. Sub Criteria for Managing Resistance:	
9	III.	- Ready to Make Changes - Build Trust And Positive Relationships	0,0000
		VI. Motivation Sub Criteria:	
10	V.	- Give bonuses and additional salaries - Recognition of the Work Results	0,0000

5. Conclusion

Based on the results of the study, it can be concluded that:

1) Obtained Key Success Factors for Implementing the Last Planner System in Construction Work are 10 criteria in Table 4.13 that have a value of consistency ratio below 0.1 or 10% ie 0.08 or 8%, then the assessment of the pairwise comparison between criteria is consistent and as much 24 sub-criteria in Figure 4.3 which have a value of consistency ratio below 0.1 or 10%, namely 0.07 or 7%, then the assessment of the pairwise comparison between sub-criteria is consistent.
2) AHP weighting results The Key Factors for Success of the Last Planner System in Construction Work of each of the biggest criteria is the stakeholder criteria with the highest priority weighting with a global weight of 0.2279 and the second priority is the support of top management with a global weight of 0.2094. Likewise, from each of the biggest sub-criteria is the sub-criteria of stakeholder support for the implementation of LPS with the highest priority weighting with a global weight of 0.1812 and the second priority is top management support for the implementation of the LPS with a global weight of 0.1397.

References

[1] Kaming, P.F., Olomolaiye, P.O, Holt, G.D. and Harris, F.C. (1997). "Factors Influencing Craftmen's Productivity In Indonesia. "International Journal of Project Management. Vol. 15, 21-30. https://doi.org/10.1016/S0263-7863(96)00019-1.

[2] Ballard, G., Tommelein, I., Koskela, L. and Howell, G (2002) 'Lean Construction Tools and Techniques', in Best and De Valence (Eds), Design and Construction: Building in Value, pp.227-255, Butterworth-Heinemann, Oxford.

[3] Ballard, G. and Howell, G. (2003) An update to Last Planner, Proceedings of the 11th IGLC Conference, Virginia, USA.

[4] Ballard, G., (2000). "*The Last Planner System of Production Control (Theses)*". School of Civil Engineering Faculty of Engineering the University of Birmingham. UK.

[5] Koskela, L. (1992). *Application of The New Production Philosophy to Construction*. Stanford University, CIFE Technical Report # 72.

[6] Adelback, T., dan Johansson, N. (2013), "Success Factors in Large Infrastructure Projects: The Contractor's Perspective". Thesis, Chalmers University of Technology

[7] Al-Momani, A. (2000) Construction Delay: A Quantitative Analysis, International Journal of Project Management, 18(1):51-59. https://doi.org/10.1016/S0263-7863(98)00060-X.

[8] Lim, C.S dan Mohamed, M.Z. (1999), "Criteria of Project Success: An Exploratory Re-examination", International Journal of Project Management, Vol. 17, 243-248. https://doi.org/10.1016/S0263-7863(98)00040-4.

[9] Ballard, G. (1997) Lookahead Planning, the missing link to production control, Proceedings 5th IGLC Conference, Griffith University, Gold Coast, Australia.

[10] Lincoln, Yvonna S & Egon G. Guba. (1985). *Naturalistic Inquiry*. California: Sage. https://doi.org/10.1016/0147-1767(85)90062-8.

[11] Liu, M. and Ballard, G. (2008), "Improving labour productivity through production control" In:, Tzortzopoulos, P. and Kagioglou, M.(Eds.),16th Annual Conference of the International Group for Lean Construction, Manchester, UK, 16-18 July, 2008, pp 657-666.

[12] Mansfield, N., Ugwu, O. and Doran, T. (1994) Causes of delay and cost overruns in Nigerian construction projects. International Journal of Project Management, 12(4):254-260. https://doi.org/10.1016/0263-7863(94)90050-7.

[13] Massachusetts Port Authority Capital Program and Enviromental Affairs. (2019). "*Last Planner System Minimum Standards Guide*". Amerika Serikat.

[14] Mossman, Alan. (2015). "*Last Planner: 5 + 1 Crucial & Collaborative Conversation for Preditable Design & Construction Delivery*".

[15] Odeh, A., and Battaineh, H. (2002) Causes of Construction Delay: Traditional Contracts, International Journal of Project Management, 20(1):67-73. https://doi.org/10.1016/S0263-7863(00)00037-5.

[16] Ogunlana, S., and Promkuntong K. (1996) "Construction delays in a fast-growing economy: comparing Thailand with other economies" International Journal of Project Management, 14(1):37-45. https://doi.org/10.1016/0263-7863(95)00052-6.

[17] Patel, A. (2011). The Last Planner System for Reliable Project Delivery (Thesis). Arlington, University of Texas, U.S.A.

[18] Saaty, T. L. (1980). *The Analytic Hierarchy Process.* New York.: McGraw-Hill. https://doi.org/10.21236/ADA214804.

[19] Saaty, T. (1990). How to make a decision the analytic hierarchy process. *European Journal of Operation Researc*, *48*, 9–26. https://doi.org/10.1016/0377-2217(90)90057-I.

[20] Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International Journal of Services Sciences*, *1*(1), 83. https://doi.org/10.1504/IJSSCI.2008.017590.

[21] Sanvido, V., Grobler, F., Parfitt, K., dan Guvenis, M., Coyle, M. (1992), "Critical Success Factors for Construction Projects", ASCE, Vol. 118, 94-111. https://doi.org/10.1061/(ASCE)0733-9364(1992)118:1(94).

[22] Serpell, A., Venturi, A. and Contreras, J. (1995). Characterization of waste in building construction project. *In: L.F. Alarcon, ed. Lean Construction.* Rotterdam: A.A. Balkema, 67-77.

[23] Steven, S., Robby, R., & Andi, A. (2013). Perhitungan Percent Plan Completed Dan Identifikasi Faktor Tidak Tercapainya Rencana Pekerjaan Pada Suatu Proyek Konstruksi. Jurnal Dimensi Pratama Teknik Sipil, 2(2).