OPTIMIZATION OF LEAN CONSTRUCTION-BASED PROJECT PERFORMANCE ON HIGH-RISE BUILDING STRUCTURE WORK OF PRECAST AND HALF SLAB BEAM SYSTEMS USING THE RELATIVE IMPORTANCE INDEX (RII) METHOD

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Abstract

In the construction of high rise buildings, beams and slabs are one of the main elements where both function is as a load distribution element. Using precast beams and half slabs simultaneously for high-rise buildings is a feasible innovation because it is expected that usingo precast elements together will improve project performance. However, in practice there are several obstacles in using of this method so that work pr oductivity becomes less than optimal. Using a questionnaire-based data analysis method, this study examines the application of lean construction to use these materials. The results of the study's result indicate that the application of lean construction to high-rise building structures for precast beam and half slab systems has been proven to have produced 7 variables with 35 waste factors. must be watched out and eliminated in the implementation of the work because all these factors and variables can reduce project performance so that if they can be eliminated it will increase the productivity of project performance.

Keywords: Building construction, Precast beam, Half slab, Lean construction, Project performance

1. INTRODUCTION

The growth of construction projects for high-rise buildings has recently increased where many high-rise buildings are built, especially in urban areas to meet residential needs such as hotels, apartments and for office needs. According to Ismail,, Rahman, & Memon (2013) The construction industry is very important in the development of a country and can enhance economic development. Meanwhile, according to Enshassi, Mohamed, & Abushaban (2009) Time, cost and quality are the three dimensions of performance evaluation that are the most dominant failures of construction projects are closely related to problems and failures in performance. while according to Dulaimi and Tanamas (2009), the familiar problems in the construction project environment are low productivity, low quality, weak coordination, expensive costs, and others. This certainly makes service users and service providers and all stakeholders involved in construction projects will always make innovations in their implementation, especially in an effort to improve project performance. According to Dulaimi and Tanamas (2009) The selection of the right construction method is one of the things that can be done in order to complete the project on time for the efficiency of the implementation of the work.

One of the construction methods to choose from is the precast concrete method. According to Nikakhtar et.al. (2018) This precast concrete method is considered a method that is considered more effective and superior when compared to conventional methods.

In the structural work of high-rise buildings, beams and slabs are one of the main elements where the function of the beam is as a load channeling element to the column while the slab is a horizontal structural element that functions to channel the load to the vertical support frame of a structural system, then the design used must be able to support and distribute the load optimally so that the material selected and used must be in accordance with the regulations of the National Standard Indonesia for building high-rise buildings. There are several comparisons in the use of Wood, Steel and Concrete materials as can be seen in Table 1.

Table1. Qualitative comparison of wood, steel and concrete

Aspects	WOOD	STEEL	CONCRETE	
			Conventional	Preprint
Procurement	The more limited	Mainly Imports	Easy	Easy
Demand	Many	Many	Most	Enough
Implementation	Like, Dirty	Fast, clean	Old, dirty	Fast, clean
Maintenance	High Cost	High cost	Medium cost	Medium cost
Quality	Depending on the species	Tall	Medium-high	Tall
Price	Getting more expensive	Expensive	Cheaper	More mrah
Workforce	Many	Many	Many	Many
Milieu	Unfriendly	friendly	Many	Many
Standard	There is (being updated)	There is (being updated)	There is (being updated)	None yet (currently being drafted)

Source : Books and construction (Rahman, 2010)

The use of precast *beams and half slabs* simultaneously for high-level buildings is an innovation that is very feasible to use because it is hoped that the use of these two structural elements together with the *precast* system will improve project performance in terms of cost budget, speed of implementation time and also quality of work, but in practice this still cannot be done optimally because there are still many constraints that occur in the field so that this affects the performance of the project. According to (lean construction Indonesia institute) based on the research of several experts in the field of construction in America, it turns out that in every construction carried out there are only 40% of activities that actually have added value (non-value added), while the other 60% have no added value (non-value added). According to Gaspersz, (2007) The process of running projects that are less efficient (in-efficiency) is caused by the large number of non-value adding activities or what is often called waste. According to Nikakhtar et al., (2015). One of the most effective approaches to reducing delays in construction projects is through the use of lean construction

The research objectives discussed in this study are:

a. Knowing the application *of lean construction* in building structure work Building level high level precast beam system and *half slab*
b. Knowing what important factors affect project performance on high-level building structure work *precast* and *half slab* beam systems

2. METHOD

This analysis is expected to produce a study model of the application of lean construction to the work of precast beam system structures and half slabs for high-level buildings so that later it can increase work productivity and reduce work waste that has been occurring in the field due to the use of these materials. while according to Yin (2002) to determine the research method there are several things that It is necessary to consider, among others, the type of questions to be asked, the control of the events to be studied to the focus of the events. In order to answer the research questions asked, this research uses a research strategy in the form of case studies. To conduct research scientifically, it is necessary to have stages or sequences that are adjusted to the research framework that has been compiled in the form of a flow chart. The flow chart is prepared based on the formulation and research objectives to be achieved by referring to the feasibility study of the project.

A research variable is an attribute or trait or value of a person, object or activity that has certain variations that have been determined by the researcher to be studied so that conclusions can be drawn. In this case, the variabel or object that will later be examined is the precast beam and half slab which

will later examine the application of lean construction to work that uses these material elements and removes waste to improve project performance.

According to Arikunto (2010), research instruments are tools selected and used by researchers in collecting data so that their presentation can be more systematic. Meanwhile, according to Suryabrata (2003) research instruments are tools used to record the state and activity of psychological attributes. So it can be concluded that research instruments are tools used by researchers to collect qualitative and quantitative data and information about the variables under study. The instruments used in this study were in the form of material data on precast beams and half slabs in high-level buildings. While this research will use two (2) types of data, namely; Primary data, obtained from questionnaires as well as secondary data, obtained from the results of literature studies such as books, references, journals and other research related to the research being carried out. Meanwhile, the analysis model uses the relative importance index (RII) method by looking for the factors that most influence the productivity of the use of precast and half slab beam materials in high-level buildings.

3. RESULTS AND DISCUSSION

Research variables

The data collection method is carried out through the dissemination of questionnaires with question items obtained from predetermined research variables based on literature studies, which are related to the factors of lean construction use of construction projects. The application used in analyzing these data is using Microsoft Excel 2010 software with the Relative Important Index (RII) method. The result will be displayed in the form of a table. Furthermore, for data collection with the distribution of questionnaires, it is preceded by a validation stage by experts to be then distributed to correspondents. The data that has been obtained is then tested for validity and reliability.

There are several variables and factors used for this research. Where these variables are identified in several factors that are expected to be variables related to the main variables. The purpose of using these variables is to later increase the productivity of using *half slabs* and *precast* beams in high-rise buildings. The selection of this variable by taking various references to previous studies The variables used in this study are as can be seen in Table 2

Table 2. Research variables used

No.	Variable
1	Human Resources (Staff)
2	Materials and Materials
3	Workforce
4	Equipment
5	Working Methods
6	Site Management
7	External Factors

Source : Processed products

To produce the expected research, sub-variable identification of factors related to the main variables of the study is carried out, the goal is to increase the productivity of construction work so as to make project performance better. The sub-variable factors used in this study can be seen in Table 3 as follows:

Table 3. Variables and research factors used

No.	Variable	Factor
1	Human Resources (Staff)	a) Lack of skills or abilities b) Inexperienced c) Lack of Communication d) Lack of Oversight

		e) No instructions f) Often absent from the field g) Quality control does not work h) Safety none
2	Materials and Materials	a) Late arrival materials b) Damaged or unusable material c) Defective and cracked materials d) Material mis-produced or not in accordance with specifications e) The material is not yet aged f) Damaged means of production g) Material is out of stock
3	Workforce	a) Misinstallation until disassembly occurs b) Lack of foreman c) Incomplete PPE d) Unsuitable wages e) Inexperienced f) Lack of Skill g) Too much overtime h) Late dating or undisciplined i) Payments are not smooth
4	Equipment	a) The technology of the equipment used is less sophisticated b) Limited equipment range c) Difficult equipment operations d) Incomplete equipment e) Limited amount of equipment used f) Improper equipment selection
5	Working Methods	a) Improper selection of methods b) Unclear and elusive working image c) The method does not match the work site d) Messy work cycle e) No Safety work
6	Site Management	a) Improper location of material placement b) Improper placement of tools c) Queue in and out of the project d) Poor road access e) Arbitrary schedule f) Improper division of zones
7	External Factors	a) Frequent rainy weather b) Densely populated environmental conditions c) Traffic around the location is congested and often congested d) There is a request for design changes e) Less material transport fleet

Preparation of research instruments

Based on the identification of variables in the table above, research instruments are arranged in the form of question items or statements. The items of the question or statement are arranged by transormating the existing factors. In the questionnaire distributed to respondents, respondents' participation is to choose the answers that have been provided on a scale of 1-5, from varied answer criteria. The scale is designed in such a way that scale 1 is the least expected answer choice (*unexpected* answer) and scale 5 is the most expected answer choice (expected *answer*). In the preparation of the

research instrument here, the questionnaire used has been compiled completely so that respondents only choose one answer that suits their choice.

Overview for respondents

The respondents for collecting this questionnaire data are actors and users of construction services from both implementing contractors, supervisory consultants and experts who have experienced in the field of high-rise building projects for more than 5 (five) years and have a higher education background.

Analysis of questionnaire results

At this stage, an analysis of the results of the questionnaire that has been answered by the respondent is carried out where each respondent is given a question with the answers that have been provided then later the data is processed using the help of Software. Later at each stage of processing, testing is carried out gradually so that the data obtained can produce good data validity and can produce the right regression model

Primary data collection

This study used primary data obtained from filling out questionnaires by as many as 40 respondents, all of whom were staff working on the XYZ Apartment project. The primary data obtained will be analyzed to identify what important variables and factors can affect the productivity of the use of *half slabs* and *precast beams* in high-rise buildings.

Distribution of research samples

It is known that the total population of staff working for the technical field both from the executing contractor and from the supervisory consultant is as many as 40 people, so according to the table of Isaac and Michael for an error rate of 5% a sample of 36 respondents is needed, in this case the author distributed 40 questionnaires and 38 have been successfully filled out and returned by respondents, then the number of samples has met the research requirements with a confidence level of more than 95%.

Classification of research samples

Based on the results of filling out the questionnaire, most of the education levels owned by respondents were S1 (84.21%) while the rest were S2 (10.53%) and D3 (5.26%). This shows that many respondents already have higher education

Secondary data collection (questionnaire)

Secondary data, that is, data obtained from journals and other literature related to this study. The data obtained are processed and presented and used as the author's guidelines in discussing research results.

Validity test

The validity test was carried out by correlating each question to the total score, then compared with the table r value (Pearson Product-Moment Correlation Coefficient), with a level of significance value of 5%. This indicates that the tolerable error rate in this investigation is 5%. Thus, the confidence level in this study is as large as
95%, while pearson's r coefficient value for the number of respondents (N) = 38, is 0.320.

Table 4. Validity test resultsVariable

	r Count	r Table	Information	Variable	r Count	r Table	Information
1	0.438	0.320	VALID	27	0.078	0.320	INVALID
2	0.384	0.320	VALID	28	0.577	0.320	VALID

3	0.364	0.320	VALID	29	0.378	0.320	VALID
4	0.359	0.320	VALID	30	0.364	0.320	VALID
5	0.342	0.320	VALID	31	0.193	0.320	INVALID
6	0.409	0.320	VALID	32	0.033	0.320	INVALID
7	0.439	0.320	VALID	33	0.403	0.320	VALID
8	0.154	0.320	INVALID	34	0.393	0.320	VALID
9	0.059	0.320	INVALID	35	0.446	0.320	VALID
10	0.430	0.320	VALID	36	0.367	0.320	VALID
11	0.364	0.320	VALID	37	0.226	0.320	INVALID
12	0.365	0.320	VALID	38	0.392	0.320	VALID
13	0.408	0.320	VALID	39	0.355	0.320	VALID
14	0.412	0.320	VALID	40	0.031	0.320	INVALID
15	0.392	0.320	VALID	41	0.386	0.320	VALID
16	0.021	0.320	INVALID	42	0.343	0.320	VALID
17	0.209	0.320	INVALID	43	0.345	0.320	VALID
18	0.362	0.320	VALID	44	0.062	0.320	INVALID
19	0.523	0.320	VALID	45	0.426	0.320	VALID
20	0.580	0.320	VALID	46	0.407	0.320	VALID
21	0.402	0.320	VALID				
22	0.367	0.320	VALID				
23	0.688	0.320	VALID				
24	0.353	0.320	VALID				
25	0.367	0.320	VALID				
26	0.100	0.320	INVALID				

Based on the results of the Validity test on 46 variables, 11 invalid data were obtained. So with the validation test carried out, it can be believed that each question item in this questionnaire can provide valid results, namely provided that r count > r table.

Reliability test

The reliability test is an advanced stage in factor analysis after testing the validity of the constituent variables of the formed factors. Reliability shows an understanding that an instrument is quite trustworthy and reliable, using Cornbach Alpha analysis, A questionnaire is considered reliable if the Cornbach Alpha coefficient is greater than or equal to 0.6 (Arikunto, 2010) while Sekaran (2006) states that a research instrument indicates adequate reliability if the alpha crombach coefficient is greater than or equal to 0.70. However, for some specific cases, a factor with a component of less than 3 can have a crombach alpha < 0.7, for such cases a reliability reference is used according to Guilford in Sugiyono (2007:183) which divides the level of reliability in 4 criteria, namely as can be seen in Table 5 below:

Table 5. Coefficient of reability

Criterion	Coefficient of Reliability
Very Reliable	>0.900
Reliable	0,700-0,900
Simply Reliable	0,400-0,700
Reliable	0,200-0,400
Less Reliable	<0.200

(Source : Sugiyono, 2012)

Based on Table 5 above the adequacy of the factor component is declared unreliable if it has a cronbach's alpha coefficient below 0.2, at cronbach's alpha coefficient between 0.2 to 0.4 it is declared

less reliable and on cronbach's alpha coefficient between 0.4 to 0.7 it has been declared sufficiently reliable. So after analyzing the data using the help of the Microsoft Excel program, the value of Cronbach's Alpha coefficient was obtained by 0.827, which means that the factor component is included in the reliable category.

Relative important index (rii) analysis

Relative Important Index (RII) analysis is an analytical tool that allows a relative quantifiability, where the higher the rating (rating), the higher the influence given by the variables (Rusdiani, 2017). This stage is carried out after the respondent data is collected, and then the relative importance index (RII) calculation is carried out. The determination of the level of importance indicated by the parties concerned is used to measure the relative importance index value of each factor. The Relative Importance Index (RII) is used to analyze various factors affecting the productivity of workers in construction related to project implementation. The score for each factor is obtained through the summation of the respondent's answer score. The results of this analysis calculation show the ranking of the overall factors and further determine the influence of the strength of each of these factors. Once the most dominant factors are obtained, eating will be attempted to analyze the root cause of these factors. So to determine the ranking of factors that are key in eliminating various *wastes* in the use of precast beams and half *slabs* in high-rise building construction projects, it is carried out using Relative Important Index (RII) analysis so that later it is known the views of each party who is or has been involved in the use of *precast* beam and *half slab* materials. Such on high-rise buildings. As for the Calculation of Relative Important Index (RII) Analysis using the formula:

$$RII = \Sigma W (A X N)$$

Where:
A = Highest weight (in the study 5)
N = Total number of respondents
W = Weight to be given for the factor dominant (with a range of 1-5)

After calculating as the formula above, with the calculation of the Relative Important Index (RII) on the factors that influence the application *of lean construction* in the use of *precast* beams and *half slabs* in high-rise building construction projects based on the group of variables, the most dominant variables are obtained, from the calculation it is known which factor is the most or very dominant (0.834-1.000), dominant (0.668-0.833) somewhat dominant (0.501-0.667), less dominant (0.334-0.500), Non-dominant (0.168-0.333), Very non-dominant (0.000-0.167).

The results of the index values of all factors in all calculations can be seen as in Table 6 below:

Table 6. Table of index values

No.	Variable		Factor	Index RII
1	Human Resources (Staff)	X1	Lack of skills or abilities	0.937
2		X2	Inexperienced	0.921
3		X3	Lack of Communication	0.868
4		X4	Lack of Oversight	0.916
5		X5	No instructions	0.858
6		X6	Often not in the field	0.905
7		X7	Quality control does not work	0.868
8	Materials and Materials	X10	Damaged or unusable material	0.895
9		X11	Defective and cracked materials	0.895
10		X12	Material misproduced or not according to specifications	0.921
11		X13	The material is not yet aged	0.916

12		X14	Broken means of production	0.900
13		X15	Material out of stock	0.921
14		X18	Incomplete PPE	0.895
15		X19	Unsuitable wages	0.911
16		X20	Inexperienced	0.911
17	Workforce	X21	Less Skilled	0.916
18		X22	Too much overtime	0.911
19		X23	Late arrival or undisciplined	0.895
20		X24	Payments are less lancer	0.889
21		X25	The technology of the equipment used is less sophisticated	0.884
22		X28	The equipment used is incomplete	0.884
23	Equipment	X29	Limited amount of equipment used	0.921
24		X30	Improper equipment selection	0.900
25		X33	Method does not suit the work site	0.889
26		X34	Messy work cycle	0.921
27	Working Methods	X35	No Safety jobs	0.900
28	Site Management	X36	Improper location of material placement	0.905
29		X38	Paths in and out of the project queue	0.868
30		X39	Poor road access	0.879
31		X41	Improper division of zones	0.889
32		X42	Frequent rainy weather	0.879
33	External Factors	X43	Densely populated environmental conditions	0.874
34		X45	Access roads to the site are damaged and often jammed	0.889
35		X46	Less material transport fleet	0.932

The results of the Relative Important Index (RII) Analysis as shown in Table 6 show that there are 7 (seven) variables with 35 (thirty-five) factors used as indicators of this research process. The ranking of each of the 7 (seven) variables can be seen in Table 7 below.

Table 7. Table of variable index values

Rank	Existing	Rank	After Prosess	Factor	Total	*Mean*
1	HR (Staff)	1	Materials and Materials	6	5.447	0.908
2	Materials and Materials	2	Workforce	7	6.326	0.904
3	Workforce	3	Working Methods	3	2.711	0.904
4	Equipment	4	Equipment	4	3.589	0.897
5	Working Methods	5	HR (Staff)	7	6.274	0.896
6	Site Management	6	External Factors	4	3.574	0.893
7	External Factors	7	*Site Management*	4	3.574	0.893

From the results of Table 7 above, it can be seen that there is a change from existing to after research, this is of course directly proportional to the constraints that often occur in the field. Of course, this must be eliminated in accordance with each obstacle faced by finding solutions to these problems or obstacles so that later the project performance will be even better. The first is to start from materials and materials, this factor becomes very important because in the work of *precast* beams and *half slabs* materials and materials become the main work in the course of work both in production activities and

in installation activities, so that if you experience problems with these factors, it can be ascertained that all work activities will stop. In the second rank, the main factor that is an obstacle is labor, as well as materials and materials, this labor factor also greatly affects the process of producing goods and installing goods because all require labor in the two activity processes so that if there are obstacles to these factors, it will hinder and affect the performance or results of work.

The main factor that ranks third in the constraints is the working method factor. In every construction activity there is always a work method used so that if you use a method that is not suitable work, of course, it will make project performance not good, evaluation of work methods is very necessary in several implementations so that improvisation or renewal occurs in every construction activity and eliminates any obstacles that arise during the process of work activities. The fourth rank is equipment, the use of precast beams and half slabs will not be separated from the use of equipment or heavy equipment used. Equipment is an important part of both the production process and the installation process, if there are obstacles to the equipment, it will certainly hinder the work in the field. So this must be anticipated by always checking the tools used in order to support the process of activities that are being carried out in the field. The fifth rank is human resources (staff), all activities carried out in the field must be obtained controlled and can be supervised so that the quality of work, work costs and implementation time are in accordance with what has been planned. However, this is also not easy because it also needs several supporting factors so that it can be realized. Then the sixth rank is an external factor, there are a lot of several project activities, both production activities and installation activities that are affected by external factors so that solutions need to be found so as not to hinder project performance. And for the last or seventh rank is site management, this factor is very important because with the arrangement of a construction activity, all production and installation activities become very smooth and run well. However, if there are obstacles in this factor, eating will certainly hinder the stages of work activities so that the production and installation processes will also be hampered.

4. CONCLUSION

The application *of lean construction* in high-level building structure work for *precast* beam systems and *half slabs* has proven to have produced 7 variables with 35 waste factors that must be watched out for and eliminated in the implementation of the work because all factors and variables can interfere with and reduce project performance so that if later it can be eliminated it will increase project performance productivity.

Important factors that affect project performance in high-level building structure work *precast* beam systems and *half slabs* the first is for human resources (staff) variables with the factors being lack of skills or abilities in human resources, inexperienced, lack of supervision, often not in the field, lack of communication, quality control that is not running and no instructions, Then for material and material variables with the factors are the material is wrong production or not according to specifications, the material is out of stock, the production tools are damaged, the material is damaged or cannot be used, the material is defective and cracked, and the material is not yet aged while for labor variables with factors are less skilled workers, inexperienced, too much overtime, wages that are not suitable, the use of incomplete personal protective equipment, workers arriving late and not being disciplined, payment is less directed, then for equipment variables the important factors are j umlah the equipment used is limited, the selection of equipment is not right, the equipment technology used is less sophisticated, the equipment used is incomplete then for the variables of work methods the important factors are messy work cycle, no work safety, methods do not match the work site and for *site management* variables the important factors are improper material placement location, improper zone division, poor road access, queued project exit and for external factors the important factor is the material transport fleet is lacking, road access to the site is damaged and often congested, frequent rainy weather and densely populated environmental conditions

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