Analysis of Factors Affecting Labor Productivity of Upper Structure Work on the Hurun Beach Resort Project Using the AHP (*Analytic Hierarchy Process*)

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Abstract

Development and project development in Indonesia is very important and is expected to have a good impact on the economy of this country. To achieve reliable development, it is necessary to manage human resources with the aim of increasing construction productivity. The factor influencing productivity is one of the benchmarks for the success of construction development implementation. This study aims to analyze the factors and occupations that have a relative effect on labor productivity in the Hurun Beach Resort Project. The AHP method is the research method used to carry out the analysis in this study. This is because decision-making criteria and alternatives become a reference to obtain achievements so that the percentage of the desired productivity factor can be known. Based on the results of the sub-criteria analysis, the relatively influential factor is the shop drawing with a weight of 0.19432, the second is the experience factor of 0.11948, and the third is the factor of adding working hours 0.10936. After analyzing the sub-criteria and then getting the final weight, the alternative superstructure work that is relatively influential is formwork work with a weight of 0.03413, the second is ironwork 0.03049, and the third is casting work 0, 0207.

Keywords: *productivity factor, labor, hurun beach resort, level, analytic hierarchy process.*

I. INTRODUCTION

The role of human resources is very large and is one of the supporting factors for the success of the project. With human resources that have a positive impact on a construction, the person in charge must understand the level of labor productivity in order to organize and manage these human resources [1]. Workers are required to be able to work effectively and efficiently according to the number of hours worked and the volume of work that has been planned. So that it can be expected to be factors that support the progress and smoothness of the project as a whole.

Existing problems can be found from various circumstances, both from humans themselves or their environment. The intensity ratio scale of a problem needs to be analyzed to find out how much influence labor productivity has. This study aims to analyze the factors and occupations that have a relative influence on labor productivity in the Hurun Beach Resort Project.

Several previous studies that have examined the productivity factor, namely Ramadhan [2] analyzed the factors causing delays in the construction of the SCE project. By using the AHP method, the analysis of this study found that the factor of available equipment that did not function properly was the main factor causing delays in the SCE project. Edulan [1] analyzed the factors influencing the productivity of masons at the Grand Malebu Hotel. The results of this study indicate that the factors that influence productivity are experience, age, weather, and K3.

In project development, the intensity of implementation time, cost increase, and work results are not in accordance with what has been planned where the three problems are the dominant performance scope studied by Agsarini [3] regarding the influence of factors on project performance. The analysis was carried out using the canonical correlation method. The results of the analysis show that internal factors have a strong influence on the performance of project development. There are many other studies regarding the factors influencing labor productivity with various factors. Therefore, this research can be used as a reference for further research.

This research was conducted at the Hurun Beach Resort Project, which is located on Jalan Pantai Mutun, Sukajaya Lempasing Village, Pesawaran Regency, Lampung, Indonesia. This study was analyzed using the AHP (Analytic Hierarchy Process) method with the achievement of knowing how much influence the factors of productivity and work were relatively influential in the project. Alternatives in this research are iron work, foundry work, and formwork work.

II. MATERIALS AND METHODS

By using the *Analytic Hierarchy Process* method, the criteria in this study there are four criteria, namely internal factors, external factors, management factors, and technical factors. Each of these criteria has a sub-criteria in which each criterion has three sub-criteria. Factors influencing labor productivity can be seen in the table below:

Table 1. Research Criteria Variables

Criteria	Sub-Citeria
Factors Internal	Experience
	Worker negligence
	Age
Factors External	Work area
	Weather
	Accuracy of arrival of materials
Factors Management	Changes to plans and specifications
	Compatibility of salary and working
	hours Increase of working hours
Factors Technical	Construction method
	Shop drawing
	Number of workers

Quantitative Decision Making Techniques

In making a decision from several practitioners there are several techniques that can be used, weighting and scoring techniques are modeling techniques that are used to make decisions based on objectives and resource constraints Weighting scores by identifying the variables that influence decisions The simplest and most frequently used formal method in quantitative decision making involves weighing and attribute assessment [4] This approach allows researchers to score weight which can be expressed as follows:

$$S = w_1S_1 + w_2S_2 + \ldots + w_nS_n = \sum_{i=1}^{n} w_iS_i$$

Where:

w_i = Weight of importance of each attribute used to make decisions

S_i = Performance level score of each attribute

After the relative contribution to the final decision is quantified, a weighted score is assigned to each attribute. Typically, the minimum performance level score is assigned a value between 0 and a maximum of 1 or 100. Weights can be varied to identify the most important attributes.

Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a method used to select from several available alternatives, based on more than one criteria on a piece of qualitative or quantitative data information. This theory is commonly used for the case of "multiple-criteria Decision-making" developed by Dr. Thomas L. Saaty in the early 1970s. Information about alternatives and selection criteria is arranged in a hierarchical form in which the relative ranking of the criteria and alternatives is determined so that weights can be calculated and priorities determined.

AHP is a decision model that has several criteria to determine the scale of discrete and continuous pair comparisons obtained from preferences and actual sizes. AHP is a decision-making method where this method involves criteria and alternatives selected based on consideration of all relevant criteria [5].

The basic principles of using the AHP method that must be understood are as follows [6]:

1. Decomposition

After determining the problem to be achieved, then perform *decomposition* which means solving a problem from the whole into its elements or commonly called determining the hierarchy. In this problem, AHP is applied to a hierarchy of criteria and alternatives.

2. Comparative judgement

At this stage, an assessment of the relative importance of the two elements is carried out at a certain level related to a higher level. The assessment of interests affects the priority of the existing elements, the results of which are written in the form of *pairwise comparison*. Then it can be seen the relative importance of the degree between the criteria.

Table 2. Pairwise Comparison Assessment

Level of Importance	**Definition**
1	Level of elements equal importance
3	One element is slightly more important than other elements
5	One element is more important than other elements
7	One element is significantly more important than other elements
9	One element is absolutely more important than other elements
2,4,6,8	Middle value between two adjoining grades

Source: Saayt, T. Lorie, 1993

Pairwise comparison matrices were obtained from several people who were the research subjects, so that paired comparison matrices could be more than one. To unify these matrices, it is necessary to combine the matrices using the *geometric mean* [7]. The formula for the *geometric mean* can be seen below:

$$G_{m.n} = \sqrt[n]{X_1 \text{ x } X_2 \text{ x } X_3 \ldots . X_n}$$

Where:

$G_{m.n}$ = *geometric* in *the m^th^* row and n^{th} column
n = the number of paired comparison matrix data
X_n = value in row and column of each pairwise comparison matrix

Table 3. Example of Comparison Matrix

	X_1	X_2	...	X_n
X_1	$A_{1.1}$	$A_{1.2}$	...	$A_{1.n}$
X_2	$A_{2.1}$	$A_{2.2}$	...	$A_{2.n}$
...	...	...	...	...
X_n	$A_{m.1}$	$A_{m.2}$	...	$A_{m.n}$

3. *Synthesis of priority*

Based on the shape of each *pairwise comparison*, the *local priority* or *Total Priority Value*. The *local priority* obtained from the *eigenvector* has been calculated using the iteration stage. The iteration stage is carried out by multiplying the same *comparison matrix*. Iteration is done at least twice to get the difference in *the eigenvector*. The difference from the *eigenvector* must be less than 0.00001, if the difference has not reached the provisions, it is necessary to do it again.

4. *Logical consistency*

At this stage, the researcher must be consistent when comparing elements based on the numerical values that have been provided. Assessment results can be tolerated if they have a *Consistency Ratio* (CR) of 10% (0.1). The AHP method measures the overall consistency of the assessment using CR which is formulated as follows:

$$\lambda_{maks} = \frac{1}{n} \sum_{i=1}^{i=n} \frac{\text{Weight Vector}}{\text{Eigenvector Value}}$$

Where:
λ_{maks} = the maximum value of the *pairwise comparisons*
n = the number of numbers in cells in a vector

In determining the value of the *Weight Vector*, multiplication is carried out between the *matrix comparison* with the *eigenvector* obtained. Then the value of maxis is used to get the *Consistency Index* (CI) value with the following equation:

$$CI = \frac{(\lambda_{maks} - n)}{n-1}$$

$$CR = \frac{CI}{RI}$$

Where:
CR = Consistency Ratio
CI = Consistency Index
RI = Random Index

If the value of CI is equal to zero, then the value of CR must also be 0 so it can be concluded that the *comparison matrix* is consistent. This can happen if the pairwise comparisons obtained have the same level of importance or in the pairwise comparison assessment, the value is one.

A comparison matrix is said to be consistent if the *Consistency Ratio* does not exceed 10%. If it is not appropriate, then the assessments made may be random or need to be revised [5].

Table 4. Random Index Value

Matrix Order	1	2	3	4	5	6	7	8
RI	0,00	0,00	0,58	0,90	1,12	1,24	1,32	1,41

Matrix Order	9	10	11	12	13	14	15
RI	1,45	1,49	1,51	1,48	1,56	1,57	1,59

Source: Saayt, T. Lorie, 1993

In this discussion, the researcher uses the AHP method so that the research results that are expected to be able to answer the formulation of the problem in this final project are the conclusions obtained based on the analysis of researchers and *expert opinions*. *Expert Opinion* is an opinion or thought obtained from experts and has intellectual ability in accordance with their field.

The characteristics of a person who are said to be *expert opinions* are determined to meet the following criteria:

1. Work for a company in the construction sector.
2. Have expertise in accordance with the field of work.

3. Minimum school education related to construction project construction or S1 construction scope.
4. Have a certificate of expertise in the field of construction work.
5. Have a minimum of 5 years of experience in construction work.

Have a position during project development. The position involved is an expert and authorized to handle the project, such as a *project manager*, *site manager*, project coordinator, *supervisor*, and or equivalent person directly working in the field.

III. RESULTS AND DISCUSSIONS

Respondent's Identity

Table 5. Respondents' Identity

No	Name	Position (20%)	Educational (20%)	Work on Project During (20%)	Experience (Tahun) (20%)	Certificate of Expertise (20%)
1.	S	Site Manager	S1	7 months	20	Yes
2.	C	Site Manager	STM	7 months	30	Yes
3.	B	Supervisor	S1	6 months	14	Yes
4.	Y	Supervisor	STM	4 months	25	No
5.	R	Supervisor	STM	5 months	27	No

Based on the data from the table above, there are several respondents who do not meet the criteria *for expert opinions*, such as recent education and ownership of certificates of expertise. However, it is still tolerable for a person's experience to work where each respondent's experience has more than 10 years.

Respondent's Weight

Based on the identity of the respondent which is used as an assessment of importance to get the respondent's weight value, it can be calculated using Griffis et al.

Table 6. Weight of Respondent

Respondend	Weight Respondent
S	0,243243
C	0,216216
B	0,202703
Y	0,162162
R	0,175676

Consistency Ratio (CR)

A consistency value test was carried out to see the consistency of respondents in providing pairwise comparison values that could affect the final results. In this study, the CR value tested on each respondent's answer has met the requirements, which must be more than 0.1. The following is a recapitulation table of consistency values

Table 7. Recapitulation of CR Values

Variable	CR
Criteria	0.0069
Factors Internal	0.0061
Factors External	0.0004
Factors Management	0.0004
Factors Technical	0.0004
Alternative to Experience	0.0026
to Negligence of Alternative Workers	0
Against Ages	0.0062
Towards Work Areas	0.0062
Alternatives To Alternative Weather	0
On Accuracy of Arrival Materials	0.0008
Alternatives To Changes in Plans and Specifications	0.001
Alternatives To Suitability Salary and Hours of Work	0
Alternatives to the Addition of Working Hours	0.0018
Alternatives to Construction Methods	0.0026
Alternative Shop drawings	0.0010
Alternatives to the Number of Workers	0.0011

Global Weight and Final Weight

The results of the pairwise comparison value data from the criteria, sub-criteria, and alternatives obtained from some of the respondent's data are then added up into one value as a *comparison matrix*. To get the value of the matrix, each value from the comparison of criteria, sub-criteria, and alternatives is used as the *geometric mean*.

Based on the calculation of the matrix comparison using the geometric equation mean criteria, sub-criteria, and alternatives then calculate the eigenvector. The eigenvector that has been obtained is used as a weight value against the criteria, sub-criteria, and alternatives.

The weight calculation is divided into two, namely global weight and final weight. Global weight is done by multiplying the value of the weight of the criteria with the value of the weight of the sub-criteria. This is done to find out how much weight each sub-criteria is in the criterion value unit so that it can be seen which sub-criteria have the most influence on labor productivity. The results of the global weight recapitulation of the criteria and sub-criteria weight values can be seen below:

Table 8. Global Weight Recapitulation

Criteria	Weight	Sub-criteria	Weight	Global Weight
Factors Internal	0.1931	Experience	0.6186	0.1194
		Worker negligence	0.1279	0.0247
		Age	0.2534	0.0489
Factors External	0.2011	Work area	0.3352	0.0674
		Weather	0.1459	0.0293
		Accuracy of arrival of materials	0.5188	0.1043
Factors Management	0.2276	Changes to plans and specifications	0.2412	0.0549
		Compatibility of salary and working	0.2783	0.0633
		hours Increase of working hours	0.4804	0.1093
Factors Technical	0.3781	Construction method	0.2344	0.0886
		Shop Drawing	0.5139	0.1943
		Number of workers	0.2515	0.0951

The final weight is carried out by multiplying the global weight value by the alternative weight value. This is done to find out how much weight each alternative has to the calculated global weight value so that it can be seen which alternative has the most influence on labor productivity.

Tablel 9. *Final Weight Calculation*

Sub-criteria	Formworks		
	Castingwork	**Ironwork**	**Bekistingwork**
Experience	0.0196	0.0485	0.0513
Worker negligence	0.0041	0.0091	0.0113
Age	0.0176	0.0160	0.0152
Work area	0.0137	0.0273	0.0279
Weather	0.0107	0.0093	0.0093
Accuracy of arrival of materials	0.0278	0.0309	0.0455
Changes to plans and specifications	0.0109	0.0188	0.0251
Compatibility of salary and working	0.0211	0.0211	0.0211
hours Increase of working hours	0.0702	0.0186	0.0204
Construction method	0.0084	0.0356	0.0445
Shop Drawing	0.0167	0.0872	0.0903
Number of workers	0.0107	0.0371	0.0472
The Average	0.0193	0.0300	0.0341

The factor of labor productivity that is relatively the most influential on the results of data processing using AHP is shop drawing with a weight value of 0.19432. The shop drawing factor is influential because the supervisory consultant in the field is often late in approving the shop drawing. This is due to the lack of communication between the field supervisor and the planning consultant. Problems Changes in the specification of detailed development drawings are also influential due to the wishes of the owner himself or due to changes in the drawings submitted by the contractor due to differences in the calculation of the structural building with the plan drawings designed by the planning consultant. Therefore, this causes the implementation of work to be hampered.

The second relatively influential labor productivity factor is the experience factor with a weighted value of 0.11948. The experience factor is one of the important factors for the workforce in the project because the more experience a person has in working, the greater the resulting productivity. The experience of the workforce on the Hurun Beach Resort Project is quite good, but there are also some workers who still lack experience in working in the construction world. Workers who have high experience are considered to have mastered or are experts in the field of work.

The third factor of labor productivity that is relatively influential is the factor of additional working hours or commonly called overtime with a weight value of 0.10936. The addition of working hours occurs due to work that is delayed and piled up so it is necessary to do additional work outside of working hours. In addition, the addition of working hours also occurred due to the desire of the implementer to accelerate the construction of the predetermined time target.

An alternative that is relatively influential on the Hurun Beach Resort Project is formwork work with a final weight value of 0.03413. This is based on the results of alternative calculations from the final weight analysis obtained from each sub-criteria global weight. In fieldwork, formwork work needs to be done as reinforcement to carry out further work.

IV. CONCLUSIONS

Based on the results of research on the Analysis of Factors Affecting Labor Productivity of Upper Structure Work on the Hurun Beach Resort Project Using the AHP (*Analytic Hierarchy Process*) method, the following conclusions can be drawn that the results of this study indicate that the relatively most influential factor is the shop drawing with a weight value of 0.19432, then the experience factor is 0.11948, and the additional working hours factor is 0.10936.

In this study, the alternative that has the most influence on the superstructure work on the Hurun Beach Resort Project is formwork work with a weight value of 0.03413, followed by ironwork of 0.03049, and casting work with a weight of 0.0207.

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