Analysis of Labor Productivity in Reinforced Concrete Structures Using Time Study Methods

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Abstract

The source of the success of a project in fulfilling the three aspects namely cost, quality, and time from one of the existing resources is the productivity of its workforce. The time study method is the right method used to determine the standard time of a job. The average value of productivity on column formwork is 10.65 m2/OH, beam formwork is 46.89 m2/OH, and plate formwork is 73.29 m2/OH. Column reinforcement work 204.51 kg/OH, beam reinforcement work 349.93 kg/OH, plate reinforcement work 287.57 kg/OH. Column casting work 7.96 m3/OH, beam casting work 25.31 m3/OH, plate casting work 15.81 m3/OH. Several factors greatly affect labor productivity. Comparison of the work productivity of reinforced concrete structures in the Ubud Market project based on the calculation results obtained the average productivity coefficient in the field of labor.

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1 Introduction

Background

The Ubud Thematic Tourism Market Construction Project is one of the ongoing construction projects in Ubud District, Gianyar Regency. This project is a concrete manifestation of improving services to the community in Gianyar Regency, namely by providing facilities and infrastructure in the form of construction of the Ubud Thematic Tourism Market.

In managing existing resources in a project, proper project management is needed, to manage all existing resources so that a project can fulfil three important aspects of the project, namely cost, quality and time (Ervianto, 2005; Asiyanto, 2005; Putra, 2009). The source of success for a project in fulfilling these three aspects from one of the existing resources is the productivity of its workforce. Labor productivity greatly influences and determines success in realizing the creation of planned construction. Workers are required to be able to work efficiently, where workers can work effectively according to the number of working hours and can complete a volume of work (Sinungan, 2018).

The time study method or time study is a method of measuring the productivity of workers in the field by determining the standard time for a job. Standard time or standard time is obtained from observations. During the observation, the observation time or observation time will be measured to find out how long it takes to complete a work activity. Then the observed time is multiplied by the work weight or rate (Nasirzadeh & Nojedehi, 2013; Poirier et al., 2015).

According to research conducted by Malamassam (2016), productivity shows that the location between the material and the workplace, the number of workers, relaxation allowances, the materials used, and the use of tools in the work are factors that influence worker productivity in reinforced concrete structure work.

Based on the results of this research, as further research, the author will conduct research on the level of labor productivity in the implementation of structural work and look for a comparison of the realized coefficient with the coefficient based on a predetermined reference, so that the best analysis can then be obtained which can be used in future planning (Diputra, 2015).

Formulation of the problem

Based on the background, the main issues to be discussed are as follows:
  1) How big is the labor productivity for reinforced concrete work on the Ubud Thematic Tourism Market Revitalization Construction construction project?
  2) What factors can hinder labor productivity in the Ubud Thematic Tourism Market Revitalization Construction construction project?

Research purpose

The objectives of this research are as follows:
  1) To determine the value of labor productivity in reinforced concrete structure work.
  2) To find out what factors can hinder labor productivity in the Ubud Thematic Tourism Market Revitalization Construction development project.

Benefits of research

The expected benefits of this research include:
  1) Able to get the productivity value of the number of workers in reinforced concrete structure work.
  2) Know the factors that hinder labor productivity for reinforced concrete work, and the results of this research can be applied to the project in question so that project work productivity increases.

Problem limitations

So that this research is more focused on existing problems, this research will be given the following problem limitations:
  1) The objects whose productivity value will be calculated are the assistant craftsman, craftsman, head craftsman

and foreman
2) The method used to analyze productivity is time study.
3) The scope of work where worker productivity will be observed is reinforced concrete work, namely installation of formwork, installation and casting, and is only limited to construction installation reinforcement work on Floor 1.
4) Observations are carried out from 08.00-17.00 every working day.

Literature Review
Labor

Labor is an important element in implementing a project because it has a large influence on the cost and completion time of a project. However, it should also be noted that humans are a complex resource and difficult to predict, so more effort and thought are needed in processing labor (Wibawa et al., 2023). Human resources (HR) are a very important factor that cannot be separated from an organization, both institutional and company. HR is also the key that determines the company's development. In essence, human resources are humans who are employed in an organization as movers, thinkers and planners to achieve the organization's goals (Sinungan, 2018).

Human resource planning is an analysis and identification process carried out by an organization regarding the need for human resources so that the organization can determine the steps that must be taken to achieve its goals. Apart from that, the importance of human resource planning is that the organization will have a clear picture of the future, and be able to anticipate shortages in the quality of the required workforce.

Productivity is a comparison of the total output in the form of goods and services at a certain time divided by the total input, which can include: man-power, management, materials, capital and machines owned (Muchdarsyah, 2003; Soeharto, 1997). Data was obtained after calculating the worker productivity value for each job. These factors include field conditions, weather at the time the work is carried out, availability of materials, number of workers and relaxation.

$$P = O/I$$

In where:
P = Productivity (m^2/ hour)
O = *Output* (m2)
I = *Input* (hour)

In general, productivity is a comparison between output and input. In the construction sector, output can be seen from the quantity of work that has been done, such as cubic meters of excavation or embankment, or square meters for plastering. Meanwhile, input is the amount of resources used such as labor, equipment and materials. Because equipment and materials are usually standard, the skill level of the workforce is one of the determining factors for productivity.

The type and intensity of project activities can change rapidly throughout its cycle so that the number of workers available. The types of skills and expertise must follow the demands of changes in ongoing activities. For this reason, a very important parameter is needed, namely labor productivity, which is used to measure work efficiency. The productivity ratio can be formulated as follows:

Productivity Ratio = (output x Standard time x 100%) / (number of workers x working time)

Worker group productivity

The productivity of a group of workers is the ability of the workforce to complete work (unit volume of work) divided into units of time, hours or days. Productivity can be used to determine the number of workers and the wages that must be paid. Labor requirements can be calculated in the following way:

Workgroup productivity = Normal volume / Duration
Labor requirements = analytical coefficient x Product. Workgroup

Because submitting a tender, labor productivity will have a big influence on the total project costs, at least in terms of the number of workers and facilities required. One approach to trying to measure the results of labor use is to use productivity index parameters (Hutasoit et al., 2017).
Utility Factor = effective working time + contributing working time x 100%/ total observations.

Analysis of the coefficient of labor needs

To determine the value of the wage unit coefficient, we need to pay attention to the basic assumption values. In determining the amount of the work wage coefficient, there are several things you need to know, including:
1) Work productivity (work results)
2) Labor or workers

To calculate the wage coefficient value, use the following formula:

Coefficient = number of workers/volume of work

Where the volume of work is the amount of work in one unit, while the number of workers is the number of workers working to complete one unit of work.

Cost of project

Costs are sacrifices or expenses made by a company or individual to obtain more benefits from the activities carried out. So the project cost itself is an expenditure incurred to build an activity, in this case, a project in the construction sector. Cost is a very important and crucial component, so in project implementation, very good cost management is required.

2   Materials and Methods

Design research

In this research, researchers used the Quantitative Descriptive method, namely direct observation (observation) and direct interviews in the field. This method was taken because the data source used by the author was a group of workers who were working, to obtain valid and actual data from the field.

Location and Time

Research Location
This research was carried out on the Ubud Thematic Tourism Market Construction Project, Gianyar Regency, Bali.
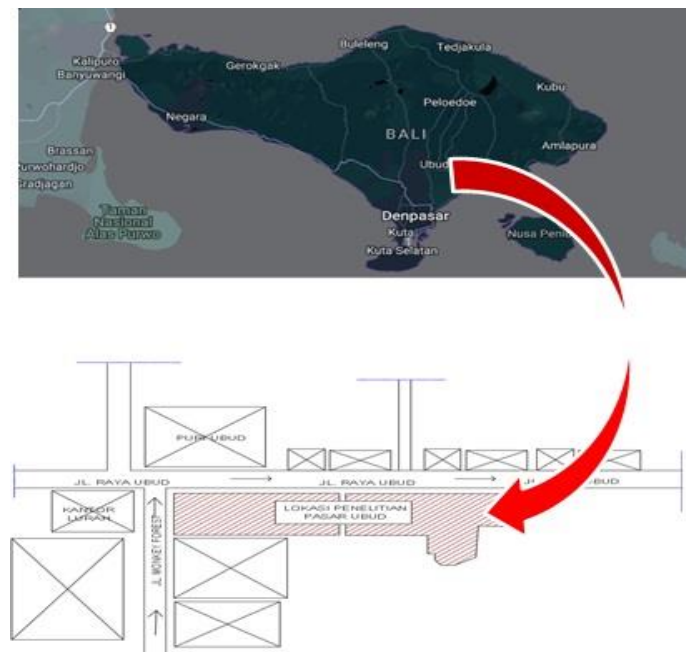
Figure 1. Map location of research

Time Research
This research was conducted during working hours, namely 08.00 – 17.00 WITA

Determining Data Source
To obtain data that corresponds to the truth for preparing this research report, the author took data related to the topic being discussed, namely by collecting existing data related to the problem being studied, these data include: Primary data, and secondary data.

Data Collection
Data collection instruments are tools selected and used by researchers in their data collection activities so that these activities are systematic and can be analyzed. To determine the data collection instrument, research must first determine the data source and data collection methods used.

Data Analysis
Data analysis is the final step of research before concluding. Direct observation (observation) is carried out to obtain data regarding the volume of actual work. Meanwhile, interviews were conducted to obtain data that is not visible, namely data on wage costs given to workers.

Research Flow Chart
Based on the background description, problem formulation, and theories that have been explained previously, the rationale for this research can be formulated as in Figure 2 below:
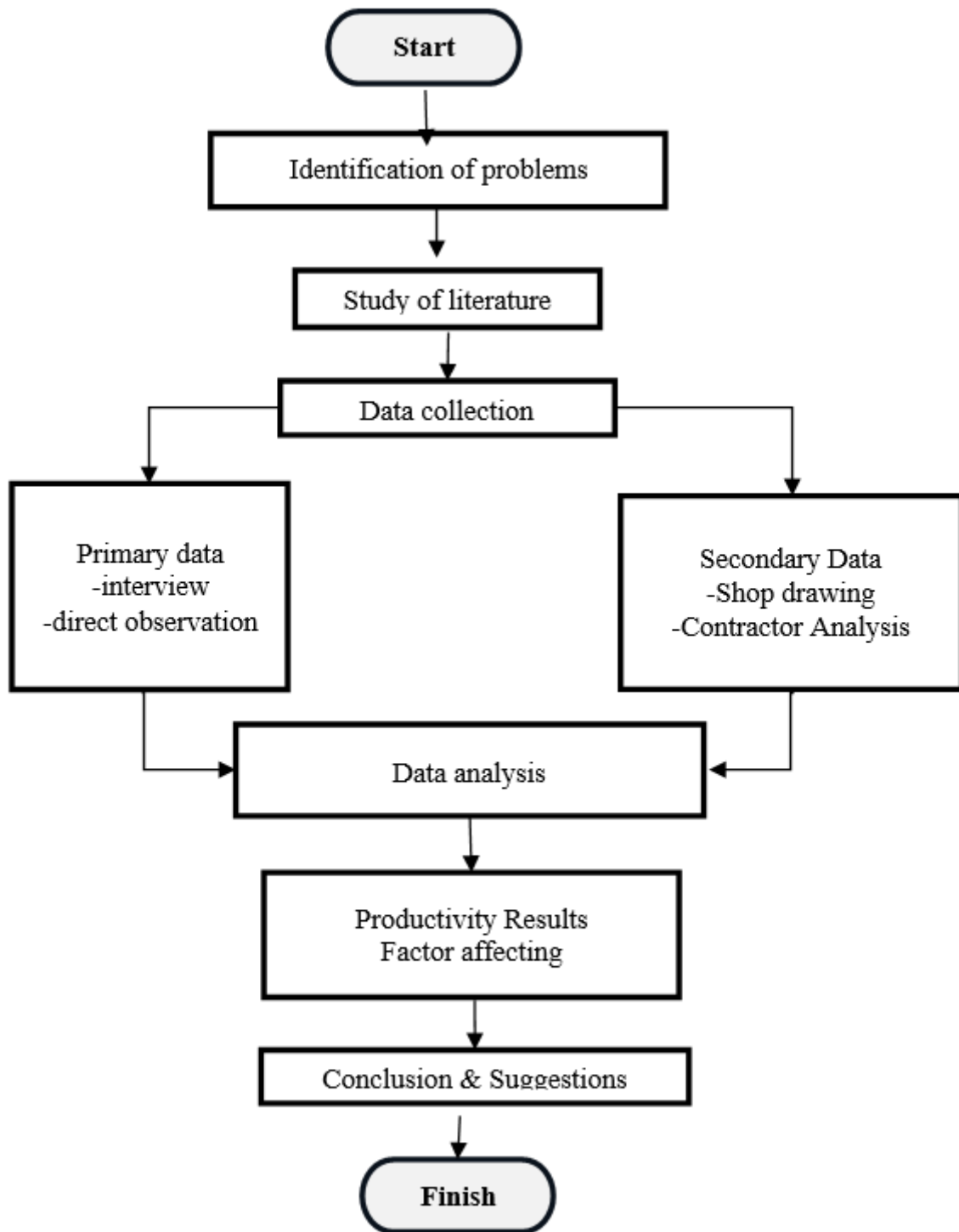
Figure 2. Research Flow Diagram

3 Results and Discussions

Scope of research

The object of research in the Ubud Thematic Tourism Market Revitalization Construction Development Project is reinforced concrete structural work, namely: Installation of column, beam and plate formwork, Reinforcement of columns, beams and plates, Casting of columns, beams and plates in the building area east.
What was studied was the productivity of the labor group during normal working hours. The overview and general information regarding the Ubud Thematic Tourism Market Revitalization Construction construction project is as follows:
Project Name: Market Revitalization Construction Development Project Ubud Tourism Thematic.
Project Location: Jl. Raya Ubud, Ubud District, Regency Gianyar.
Building Type: Thematic Market Ubud

Data collection

In this research, there are two types of data required, including secondary data and primary data. Secondary data is data obtained from contractor data, where the data is in the form of project documents, which are very relevant to be used as a reference for solving the problem formulation that has been determined. In this research, primary data was obtained directly in the field which was used as a research object for the Ubud Thematic Tourism Market Revitalization Construction Development Project (Serpella et al., 2014; Abanda et al., 2015).

Field observation

Observations in the field are regarding worker productivity in concrete structure work which consists of formwork installation work, reinforcement installation work, and casting work (Müller et al., 2014; Ahmad, 2003). Column formwork in the Ubud Market construction project uses formwork material made from plywood boards, which are stiffened with wood. The material used in this work is an inhibiting factor for the column formwork work, because the material used, namely the column belt, is still conventional, namely a wooden belt. If the plywood board is still suitable for use, it will be used in the column formwork work on the next floor.

Figure 3. Formwork installation

Installation of column reinforcement in the Ubud Market construction project is carried out on-site, which means that the column reinforcement is assembled at the place where the column will be erected. The reinforcement used has been cut and bent first at the project reinforcement fabrication site. Then the reinforcement that has been cut and bent is transported to the installation site according to requirements.

Figure 4. Reinforcement

The plate reinforcement used in the Ubud Market Construction project is the wire mesh type. The method of carrying out the work of cutting reinforcement plate reinforcement is using a bar cutter to cut rolls of wire mesh reinforcement.

Column casting on the Ubud Market construction project using a concrete pump truck. Fresh concrete from the concrete mix truck is put into the concrete pump, and then pumped to the casting site. Column casting work was carried out during the day.

Figure 5. Casting work

Plate casting is carried out simultaneously with beam casting, so the concrete pump method is suitable for carrying out this work because concrete can be pumped in large quantities and can speed up the casting process. From the dimensions of the structural elements of columns, beams and plates, the quantity of casting work can be calculated, also known as output. The results of observations in the field were carried out to find the basic time for concrete structure work which consists of formwork work, reinforcement work and casting work (Marzouk et al., 2013; Lidelöw & Simu, 2015; Cheng, 2014).

Calculation of basic time and standard time

The learning time study aims to determine the standard time for reinforced concrete structure work (McCarter & Vennesland, 2004). Field observations were carried out to obtain the basic time and then calculate the standard time for reinforced concrete structure work such as formwork work, reinforcing work and casting work. The basic time for each reinforced concrete structure job is obtained from form 2 or the field observation form for each job. In Form 2, the observation time for each element of work activity is recorded. This activity element is carried out twice because its implementation is interspersed with other activity elements. The basic time values of the two activity elements will be added up in form 3 (conclusion form).

Table 1
Summary form

Column Formwork	Summary Form						
Date: '09-09-2022 No. Observasi: 8	Basic Time (BT)						
Element Activity	1	2	3	4	5	6	Total BT
Erecting Formwork	6.45						6.45
Installing the Column Belt	64.63	33.93					98.56

From the calculations in the previous sub-chapter, it can be seen in the summary form that the total BT of the formwork erecting activity element = 6.45 and the column belt installation activity = 64.63 + 33.93 = 98.56. After getting the basic time value for each activity, the basic time value will be entered into Form 4, to add up % relaxation and contingency allowances to calculate standard time values like the formula in Chapter II.

Table 2
Conclusion form

Column Formwork Tanggal : '09-09-2022 No. Observasi: 8	Conclusion Form									
Element Activity	Total BT	Relaxation Time						Con %	Total %	Total ST
		S	P	K	L	T	M			
Erecting Formwork	6.45	8	3	1	64	1	4	5	86	7.31
Installing the Column Belt	98.56	8	3	1	64	1	4	5	86	99.42
									Total	106.73

Discussion

The following is a discussion of the results of analysis and data calculations from the research that has been carried out. This research was conducted on the construction project for the revitalization of the thematic tourism market in Ubud, Gianyar. The data collection process in this research was carried out by direct observation in the field using the time study method and interviews with related parties. The time used for data collection is normal working hours, starting at 08.30 WIB until 17.00 WIB, with a break at 12.00 WIB until 13.00 WIB. This research was carried out on Reinforced Concrete Structure work, namely:
1) Column, Beam, Slab Reinforcement Work
   In the column reinforcement work, the productivity results for each worker were 2137,462 kg/day (foreman), 673,944 kg/day (head craftsman), 760,355 kg/day (metal worker), 728,355 kg/day (helper).
   In the beam reinforcement work, the productivity results for each worker were 2137,462 kg/day (foreman), 673,944 kg/day (head craftsman), 1086,079 kg/day (metal worker), 662,141 kg/day (helper).
   In plate reinforcement work, the productivity results for each worker are 30.3 kg/day (Foreman), 30.30kg/day (head craftsman), 21.21 kg/day (metal worker), and 6.06 kg/day (prentice).
2) Column, Beam, Plate Formwork Work
   In column formwork work, the productivity results for each worker are 147,990 m2/day (foreman), 46,308 m2/day (head craftsman), 34,497 m2/day (iron craftsman), 39,365 m2/day (helper). In plate formwork work, the productivity results for each worker are 147,990 m2/day (foreman), 46,308 m2/day (head craftsman), 50,731 m2/day (iron craftsman), 65,609 m2/day (assistant craftsman). In plate formwork work, the productivity results for each worker are 147,990 m2/day (foreman), 46,308 m2/day (head craftsman), 81,169 m2/day (iron craftsman), 65,609 m2/day (helper). Column, Beam, Plate Casting Work

In the column casting work, the productivity results for each worker were 62,376 m2/day (foreman), 29,175 m2/day (head craftsman), 28,654 m2/day (iron craftsman), 27,385 m2/day (helper). In block casting work, the productivity results for each worker are 62,376 m2/day (foreman), 29,175 m2/day (head craftsman), 32,561 m2/day (iron craftsman), 34,232 m2/day (helper craftsman). In plate casting work, the productivity results for each worker are

62,376 m2/day (foreman), 29,175 m2/day (head craftsman), 39,073 m2/day (iron craftsman), 27,385 m2/day (assistant craftsman).

4 Conclusion

Based on the results of the analysis and discussion obtained in the previous chapter. So it can be concluded that the results of research on the Ubud Thematic Tourism Market Revitalization Construction Development project are as follows.

Average value of worker productivity per reinforced concrete structure job
  a) Column, beam and plate formwork work is 130.83 m2/OH.
  b) Column, beam and plate reinforcement work is 842.01 kg/OH,
  c) Column, beam and plate casting work is 49.08 m3/OH.

Factors that influence labor productivity in formwork, reinforcement and casting work are the position factor between materials, workplace, relaxation allowances factor, material used factor, and the number of workers factor.

Recommendation
Based on the results of the analysis and discussion in this research, several suggestions can be made. For further research, it is recommended to carry out research with different buildings such as docks, airports and train stations. And you can also carry out research using different and more varied data collection methods so that the data obtained is better.

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