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ANALYSIS OF LABOR PRODUCTIVITY IN FLOOR PLATE WORK USING THE WORK SAMPLING METHOD

(Case Study: Udayana University Faculty of Medicine Building and The Calna Villa)

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Abstract. Labor productivity is very important in carrying out a job. In the field of construction, the output can be seen from the quantity of work that has been done, while input is the number of resources used such as labor. This study aims to determine the amount of labor required per 1 m^2 (units of labor per day) and the standard time for labor productivity in completing 1 m^2 of floor slab work. The method of collecting primary data is the source of research data obtained directly, such as the number of workers and observation of sampling data, while secondary data is obtained from projects such as working drawings. The data is then processed using Microsoft Excel. This research is a type of quantitative research with work sampling method. From the results of research on floor slab work in the Udayana University Faculty of Medicine Building Construction project, it shows that the calculation of the volume of labor per day (units of labor per day) requires 0.011 units of labor per day masons and 0.011 units of labor per day workers and the results of calculating the standard time to complete 1 m^2 of floor slab work is 3.15 minutes/m^2. The Calna Villa project shows that the calculation of the volume of labor (units of labor per day) requires 0.039 units of labor per day masons and 0.039 units of labor per day orkers and the results of calculating the standard time to complete 1 m^2 of floor slab work is 10.37 minutes/m^2.

Keywords: Labor, Productivity, Work sampling.

1. INTRODUCTION

In the current era of globalization, every workforce in all sectors including the construction sector must have high work productivity so that they can continue to exist and compete in their field. Productivity is very important for every workforce in completing a job. The lack of awareness of the workforce on the importance of productivity is one of the reasons for the low number of jobs produced[1].

The construction of a building includes many types of work, one of the parts in the construction of the superstructure of the building is the floor slab work. Slab structure work in building construction is a very important job, considering that slab work has a large volume [2]. The large volume of work on the floor slab structure makes the floor slab work quite a lot of time. However, these elements can still be optimized in terms of spending costs resulting from material requirements and the length of time in the process by choosing other alternatives in the process.

In general, productivity is the ratio between output (results) and input (input). While Labor productivity

is the ability of employees to produce compared to the input used, an employee can be said to be productive if he can produce goods or services as expected in a short or precise time [3]. If productivity increases, this is only made possible by an increase in efficiency (time-materials-labor) and work systems, production techniques, and an increase in the skills of the workforce [3]. Each productivity improvement planning action includes the main macro factors, measurement of the importance of each factor, determination on the priority, planning a system to increase the ability of workers, and improvement the attitude of workers.

Previous research on productivity was conducted [4]. Research conducted on the analysis of construction labor productivity on ceramic floor work and wall plastering uses the work sampling method [5]. A similar method was also used to calculate the labor productivity in column and beam work. Sampling or commonly called work sampling is a technique for making many observations of the work activities of machines, processes, and workers/operators. This work measurement is classified as direct work measurement because the implementation of measurement activities must be carried out directly at the workplace to be studied. Work sampling is very suitable for making observations on work that is non-repetitive in nature and has a relatively long cycle time [6]. Sampling is done instantaneously at randomly determined times. Therefore, the use of random tables is very necessarforin this method [7]. The work sampling method is more efficient because the desired information will be obtained in a relatively short time and the cost is not too expensive [8].

This research was mainly focused on labor productivity in floor slab work. Slabs are horizontal structural elements that support dead and live loads and transmit them to the vertical framework of the structural system [9]. Plates are used in architectural structures, bridges, hydraulic structures, road pavements, airplanes, ships, and so on. A floor slab is a thin structure made of reinforced concrete and with a horizontal plane, and the load acting perpendicular to the plane of the structure [10]. This reinforced concrete slab is very stiff and has a horizontal directin so that in buildings, this plate functions as a diaphragm/horizontal behavior element which is very useful for supporting the rigidity of portal beams [11].

The work sampling method was applied to calculate the labor productivity in floor slab work. The projects used as objects in this research are the Udayana University Faculty of Medicine building project and The Calna Villa development project. The difference in the gap here is in the varied technical work, namely in the Udayana University Faculty of Medicine Building project assisted by using a tower and in The Calna Villa project not using a tower crane. This research was conducted to know the amount of labor needed for every 1 m^2 of floor slab work (units of labor per day) and knowing the standard time for labor productivity in completing 1m^2 of floor slab work using the work sampling method.

2. METHODS

2.1 Research Locations

The research was done in two locations: The Udayana University Faculty of Medicine Building Project where the location is located on Jalan P.B. Sudirman, Denpasar, Bali ,and The Calna Villa Development Project where the location is located on Jalan Raya Kuta 27, Kuta, Bali.

2.2 Data Sources

In this study, primary data collection was carried out using the work sampling method, namely momentary and periodic observations of workers carrying out floor slab work, the duration of observation was 8 hours. Observations were made at intervals every 5 minutes and the results were recorded on the work sampling observation form. Furthermore, the results of observations are grouped into productive activities and unproductive activities. Meanwhile, secondary data was obtained from data related to the project, such as working drawings on the project. The secondary data was collected through a literature study which was carried out by reading and citing information from books, theses, and internet sites.

2.3 Data Analysis

2.3.1 Work Sampling

Data uniformity testing is a useful test to ensure that the data collected comes from the same system [12]. Through this test, we can detect the presence of differences and data that are out of control which we can draw on the control chart. Such data is discarded and not used in further calculations. The data uniformity test was carried out by choosing an accuracy level of 5% and a confidence level of 95% with an absolute value of 2. To make a control chart, we first determine the control limits using equation (1) – (3)

$$\bar{P} = \frac{p_i}{n_i} x\ 100\% \quad (1)$$

$$BKA = \bar{P} + k\sqrt{\frac{\bar{P}\,(1-\bar{P})}{n}} \quad (2)$$

$$BKB = \bar{P} - k\sqrt{\frac{\bar{P}\,(1-\bar{P})}{n}} \quad (3)$$

where
pi : productive percentage on day i
ni : the number of observations made on day-i
k : price index size depends on the level of confidence
n : the average number of observations overall

2.3.2 Data Adequacy Test

The data adequacy test is a process to find out whether the data from the measurements that have been carried out are sufficient or not [13]. Observation data is said to be sufficient if N > N', i.e. the number of measurements made is greater than the number of measurements required. The formula used to calculate data adequacy is using equation (4)

$$N' = \frac{k^2(1-p)}{s^2 p} \quad (4)$$

where:
N' : The amount of theoretical data
k : Absolute price based on the confidence level
s : level of accuracy
p : productive percentage of day-i

2.3.3 Standard Time Determination

If the measurements have been completed, that is, all the data obtained has the desired uniformity, and the numbers meet the desired levels of accuracy and confidence, the next step is to calculate the standard time from the data. Standard time calculation is done using equations (5) – (8).

$$\text{Productive working hours} = \bar{P}\ x\ \text{total minutes of observation} \quad (5)$$

$$Ws = JK/\ \text{Number of units produced} \quad (6)$$

$$Wn = (p\ x\ W_s) \quad (7)$$

$$\text{Standard time} = W_n + (I\ x\ W_n) \quad (8)$$

where:
JKP : Productive working hours
Q : Productive percentage
I : Allowance (relaxation)
Ws : Cycle time
W : Normal time

The calculation of standard time was done by using following steps:

- Counting the number of observed data
- Counting the number of minutes during the observation
- Calculating productive activities
- Calculate the productive percentage
- Calculate the number of productive minutes
- Calculating cycle time (Ws)
- Calculating the adjustment factor (p), the Westinghouse method
- Calculating normal time (Wn)
- Calculating allowance (I)
- Calculating standard time (Wb)

2.3.4 Volume of workers per day (units of labor per day)

Calculation of output or volume of workers for the total workforce is carried out in field observations. The current volume calculation is used to calculate the volume of one worker for floor slab work. The way to calculate the volume of work completed by 1 worker for 1 day (units of labor per day) is by calculating the total volume of work during the study divided by the number of days during the study and divided by the number of each workforce during the study.

3. RESULTS AND DISCUSSION

3.1 Udayana University, Faculty of Medicine Building Project

Udayana University Faculty of Medicine Building Project with a land area of 2,094 m^2. The scope of work taken in this study is on the 4th floor of the building.

Sampling data collection for floor slab work was carried out for 5 days of observation starting from Sunday (22/09/2019) to Thursday (26/09/2019) for 2 builders and 2 workers who worked on slab work. The collection of Floor Plate Sampling Data is carried out for 8 working hours using the Work Sampling observation

form.

Before determining the time of visit, must determine the number of visits to be made for the calculation and the conditions are as follows:

- Working time 08:00 - 17:00
- Lunch break 12:00 - 13:00
- Long working time 9 hours – 1 hour = 8 hours

Then th number of visits $= \frac{W \times t}{s} = \frac{8 \times 60}{5} = 96$ observations, where

W = Effective working time: 8 hours
t = unit of time in minutes: 60 minutes
s = Length of each visit: 5 minutes

In this study, it was tried to take 70 random numbers from 96 random numbers, by not taking random numbers during breaks, namely from 12.00 to 13.00.

3.1.1 Calculation of Labor Volume per Day (Units of Labor per Day)

In the floor slab work, there are 4 workers consisting of 2 builders and 2 workers with 5 days of work. The volume produced for 5 days by 4 workers is 842.70 m². So in 1 day by 4 worker,s it is 842.70 m²/5 = 168.54 m². So 1 worker in 1 day can do 168.54 m²/4 = 42.13 m². Builder is 2 workers who work on floor slabs in 1 day is 84.26 m². So for 1 m² of slab work it takes 1/84.26 m² = 0.011 worker days or in other words for slab work it takes 0.011 units of labor per day masons. While workers is working on floor slabs in 1 day is 84.26 m². So for 1 m² of slab work, 1/84.26 m² = 0.011 worker days or in other words, 0.011 units of labor per day workers are required for slab work.

3.1.2 Calculating Standard Time

- Calculating the amount of observational data
  Builder 1 data = 70 data x 5 days = 350 data
  Builder 2 data = 70 data x 5 days = 350 data
  Employee data 1 = 70 data x 5 days = 350 data
  Employee data 2 = 70 data x 5 days = 350 data
  Total observational data = 1400 data
- Counting the Number of Minutes of Observation
  8 (hours) x 60 (minutes) x 5 (days) = 2400 minutes
- Calculating the Number of Observable Productive Data
  Builder 1 data = 308 data
  Builder 2 data = 307 data
  Employee data 1 = 306 data
  Employee data 2 = 305 data
  Total Data = 1226 data
- Calculating the Number of Observable Productive Data
  Productive Number = 1226 data
  Number of Observations = 1400 data
  Productive Percentage = (1226/1400) x 100 % = 87.57 %
- Calculating the Number of Productive Minutes
  Productive Percentage = 87.57 %
  Total Minutes of Observation = 2400 minutes
  Number of Productive Minutes = 87.57 % x 2400 minutes = 2101 minutes
- Calculating the number of products (volume) produced
  First Day = 150.60 m²
  Second Day = 175.00 m²
  Third Day = 160.80m²
  Fourth Day = 170.90 m²
  Fifth day = 185.40 m²
  Total Volume = 842.70 m²
- Calculating Cycle Time (Ws)
  Number of Productive Minutes= 2101 minutes
  Total Volume = 842.70 m²
  Cycle Time (Ws) = 2101 minutes/842.70 m² = 2.50 minutes/ m²

- Calculating the Adjustment Factor (p)
  Where seen from the adjustment according to *Westinghouse*, Adjustment:
  Skills = Good (C1) = 0.06
  Effort = Good (C2) = 0.02
  Condition = Excellent (B) = 0.04
  Consistency = Good (C) = 0.01
  Total = 0.13
  Total Adjustment Factor (p) = 1+0.13 = 1.13
- Calculating Normal Time (Wn)
  Cycle Time (Ws) = 2.50 minutes/ m²
  Total Adjustment Factor (p) = 1.13
  Normal Time (Wn) = p x Ws = 1.13 x 2.50 minutes/ m²
  = 2.83 minutes/ m²
- Calculating Allowance (I)

Table 1. Allowance Data in Udayana University

No	Factor	Work	Load Equivalent	Allowance (%)
1	The energy released is very light	Stand	-	6%
2	Work attitude standing on 2 feet	Supported by 2 feet	-	1%
3	Normal working movement	Limited swing	-	0%
4	Eyestrain, eyes that are cut off	Bring measuring tools	-	2%
5	Normal working temperature conditions	22-28 C	-	1%
6	The atmosphere is good	Good ventilation	-	1%
7	The state of the environment is clean, healthy, bright with low noise	-	-	0%
Amount				11%

The total amount of allowance (I) is 11%

- Calculating Standard Time (Wb)
  Normal Time = 2.83 minutes/ m²
  Allowance (I) = 11%
  Wb= Wn + (I x Wn) = 2.83 + (0.11 x 2.83)
  = 3.15 minutes/ m²

3.2 The Calna Villa Project

The Calna Villa project with a land area of 1,600 m^2. The scope of work taken in this study is in the 2nd floor lobby building. Collecting Sampling Data for Floor Slab Work for 5 days of observation starting from Tuesday (28/04/2020) to Saturday (02/05/2019) for 2 builders and 2 workers working on the slab work. Sampling Data Collection Floor slab work was carried out for 8 working hours using the Work Sampling observation form. The number of visit was calculated similarly to the one done in Udayana University Project. It was also tried to take 70 random numbers from 96 random numbers, by not taking random numbers during breaks, namely from 12.00 to 13.00.

3.2.1 Calculation of Labor Volume per Day (Units of Labor per Day)

In the floor slab work there are 4 workers consisting of 2 builders and 2 workers for 5 workdays. The volume produced for 5 days by 4 workers is 251.90 m². So in 1 day by 4 workers it is 251.90 m^2/5 = 50.38 m². So 1 worker in 1 day can do 50.38 m^2/4 = 12.60 m^2. 2 builders work on floor slabs in 1 day and was able to finish 25.20 m². So for 1 m² of slab work it takes 1/25.20 m² = 0.039 worker days or in other words for slab work it takes 0.039 units of labor per day masons.While, 2 workers who work on floor slabs in 1 day was able to finish 25.20 m². So for 1 m² of slab work, 1/25.20 m² = 0.039 worker days or in other words, 0.039 units of labor per day workers are required for slab work.

3.2.2 Calculating Standard Time

1. Calculating the amount of observational data
   Builder 1 data = 70 data x 5 days = 350 data

Builder 2 data = 70 data x 5 days = 350 data
Employee data 1 = 70 data x 5 days = 350 data
Employee data 2 = 70 data x 5 days = 350 data
Total observational data = 1400 data

2. Counting the Number of Minutes of Observation
   8 (hours) x 60 (minutes) x 5 (days) = 2400 minutes
3. Calculating the Number of Observable Productive Data
   Builder data 1 = 305 data
   Builder 2 data = 303 data
   Employee data 1 = 304 data
   Employee data 2 = 305 data
   Total Data = 1217 data
4. Calculating the Number of Observable Productive Data
   Productive Number = 1217 data
   Number of Observations = 1400 data
   Productive Percentage = (1217/1400) x 100 % = 86.92 %
5. Calculating the Number of Productive Minutes
   Productive Percentage = 86.92 %
   Total Minutes of Observation = 1920 minutes
   Numberof Productive Minutes= 86.92 % x 2400 minutes = 2086 minutes
6. Calculating the number of products (volume) produced
   First Day = 49.25 m²
   Second Day = 50.00 m²
   Third Day = 50.75 m²
   Fourth Day = 50.90 m²
   Fifth day = 51.00 m²
   Total Volume = 251.90 m^2
7. Calculating Cycle Time (Ws)
   Numberof Productive Minutes = 2086 minutes
   Total Volume = 251.90 m²
   Cycle Time (Ws) = 2086 minutes / 251.90 m² = 8.28 minutes / m²
8. Calculating the Adjustment Factor (p)
   Where seen from the adjustment according to Westinghouse, Adjustment:
   Skills = Good(C1) = 0.06
   Effort = Good(C2) = 0.02
   Condition = Excellent (B) = 0.04
   Consistency = Good (C) = 0.01
   Total = 0.13
   Total Adjustment Factor (p) = 1+0.13 = 1.13
9. Calculating Normal Time (Wn)
   Cycle Time (Ws) = 8.28 min/m²
   Total Adjustment Factor (p) = 1.13
   Normal Time (Wn) = p x Ws = 1.13 x 8.28 minutes/ m²
   = 9.35 minutes/ m²
10. Calculating Allowance (I)

Tabel 2. Allowance Data in The Calna Villas

No	Factor	Work	Load Equivalent	Allowance (%)
1	The energy released is very light	Stand	-	6%
2	Work attitude standing on 2 feet	Supported by 2 feet	-	1%
3	Normal working movement	Limited swing	-	0%
4	Eyestrain, eyes that are cut off	Bring measuring tools	-	2%
5	Normal working temperature conditions	22-28 C	-	1%
6	The atmosphere is good	Good ventilation	-	1%

7	The state of the environment is clean, healthy, bright with low noise	-	-	0%
	Amount			11%

The total amount of allowance (I) is 11%

11. Calculating Standard Time (Wb)

Normal Time = 9.35 minutes / m²
Allowance (I) = 11%
Wb= Wn + (I x Wn) = 9.35 + (0.11 x 9.35)
= 10.37 minutes/ m²

4. CONCLUSION

The calculation of floor slab work using work sampling method in Udayana University and The Clna Villas was done. The floor slab work in Udayana University Faculty of Medicine Building, 4th floor, was involving two builders and two workers. The volume produced in 1 day by 4 workers is 168.54 m^2. From the results of the calculation of the volume of labor per day (units of labor per day) it is obtained that 1 m² of floor slab work it requires 0.011 units of labor per day masons and 0.011 units of labor per day workers. So, the standard time obtained is 3.15 minutes/m^2. Even though, the project in The Calna Villa was also used same number of builders and workers, the volume produced in 1 day by 4 workers is only 50.38 m^2. Thus, for 1 m^2 of floor slab work, 0.039 units of labor per day masons and 0.039 units of labor per day workers are needed. Therefore, the standard time obtained is 10.37 minutes/m^2 which is almost three time higher than standard time for construction in Udayana University.

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