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PRODUCTIVITY AND PROCESS ANALYSIS REINFORCED CONCRETE BEAM WORK ON JIIPE GRESIK MOSQUE-BKMS CONSTRUCTION PROJECT

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ABSTRACT

Controlling labor productivity in construction projects has a very important role. For example, labor productivity in the early stages of a project can have a major impact on the accuracy of schedules or plans that have been prepared. This study aims to find out the process of implementing block work in the Mosque Construction Project-BKMS JIIPE Gresik and compare the productivity of labor in the installation of beam reinforcement with productivity standards as stated in the Minister of PUPR Regulation No. 1 of 2022.

Observations were carried out directly in the field by recording the number of workers, the volume of work, and the duration of time (working hours) on the B1 Block work for eight working days, starting at 07.00–11.00 WIB. The break time lasted at 11.00–13.00 WIB, and the work continued until 16.00 WIB. In addition, recording is also carried out at the end of working hours every day to obtain process data and worker productivity values.

The reinforced concrete block work in this project uses conventional methods which include the stages of preparation, measurement, ironing, formwork installation, checking, casting, dismantling of formwork, and treatment (*curing*) which are all carried out at the project site with the support of certain tools. The results of the observation showed that the average labor productivity (blacksmith) for the installation of B1 beam reinforcement work reached **147,390 kg/OH**, while the highest productivity was **210,532 kg/OH** and the lowest **was 93,986 kg/OH.**

The results of calculations based on the Minister of PUPR Regulation No. 1 of 2022 show that the standard productivity for blacksmith labor is **142,857 kg/OH.** Based on the results of the analysis, it was found that the average productivity of workers in the field had a value **of 1,031 times** greater than the standard of the Ministerial Regulation on PUPR.

Key Words: Productivity, Labor, Beams.

CHAPTER TITLE: INTRODUCTION

Control of labor productivity in construction projects has a very crucial role. For example, labor efficiency in the early stages of a project has a significant impact on the accuracy of the schedule or pre-arranged planning. These productivity results can be a sign of whether work will run smoothly or even experience obstacles. If worker productivity is low at the beginning of implementation, this has the potential to result in delays that ultimately cause losses for the contractor, including the possibility of receiving a performance penalty. Conversely, if work can be completed faster or worker productivity levels exceed plan, this can reduce the risk of disruption to cash flow and prevent changes in project schedules.

In compiling productivity, it is necessary to analyze the workflow of the work process that is carried out in a careful and structured manner. Good planning requires clear information about the process flow in a construction project, so that all parts of the organization and the workers involved can understand the direction of the action to be taken. Various methods are available to assess labor productivity. However, measurements often face obstacles because they are difficult to do with precision. Therefore, certain approaches are usually used to help the assessment process, one of which is the work sampling method.

Based on the problems described above, it is necessary to conduct a study on analyzing productivity and the work process. So in the preparation of this thesis we took the title "Analysis of Productivity and Process of Reinforced Concrete Beams in the Construction of Mosques-BKMS JIIPE Gresik".

LITERATURE REVIEW

Method of Implementation of Block Work

The beam work is carried out after the completion of the column work. The implementation procedure is carried out comprehensively at the project site, starting from the measurement stage, installation of formwork, ironing process, casting, to construction maintenance. Currently, there are two main methods in concrete work, namely the conventional method (concrete in situ) and the cast in site method, where concrete is cast directly on site after the formwork wooden structure is completed. In addition, there is also a precast method, which is concrete that is made first in a separate place, then reassembled after hardening and achieving the strength of the plan. The following are the stages of implementing the block work (Asroni, 2007):

1. Pack. Measurement
   Measurements are made to ensure uniformity and accuracy of the elevation of beams and plates. At this stage, *a theodolite measuring device is used.*
2. Pek. Bekisting
   The manufacture of beam and plate formwork is an important stage that is carried out simultaneously. The formwork panel should be made according to the planning drawing. Plywood cutting must be done carefully so that the result matches the planned size of the slab or block. This work was carried out directly in the field while preparing materials such as kaso 5/7, wood 6/12, and *plywood.*
3. Fabrikasi besi
   Cutting and bending of iron is carried out based on design needs using *bar cutters* and *bar bending*. The iron assembly process is carried out on site as part of the prefabricated system, so that the iron elements can be directly assembled on top of the formwork that has been installed.
4. Block grinding
   The stages of block grinding include:
   a. The arrangement of *scaffolding* with a distance of 100 cm in stages refers to the need in the field to support formwork and plates.
   b. Height adjustment of *scaffolding* beams using *a base jack* or *U-head* as a mount.
   c. The installation *of 6/12* girder wood is parallel to the *cross brace*, followed by the installation of suri beams 50 cm apart (5/7 wood), then *plywood* is installed as the base of the formwork.
   d. Once the frame is installed, the formwork side is locked using an elbow which is then reinforced with *small stirrups.*

5. Checking
   The installation of the beam formwork is considered complete when all parts have been installed correctly. Checks are carried out to ensure that the beam elevation is appropriate, using *a waterpass* or other measuring instrument. Once declared correct, the formwork is ready to be installed before the ironing work begins.
6. Beam ironing
   The stages of ironing the beams are as follows:

   a. For the ironing of the beams, at first it was manufactured in the iron lobe and then lifted using a tower crane to the location to be installed.
   b. The iron reinforcement of the beams that have been lifted is then placed on top of the beam formwork and the end of the iron beam is inserted into the column.
   c. Beam ironing is carried out through three stages of change according to the needs of the installation. In the first stage, all reinforcement is manufactured first until the beam frame is fully formed. However, there are often obstacles in the connection between the reinforcement of the column and the beam, so in the second stage the partial fabrication method is carried out. At this stage, the elongated reinforcement and the stinger reinforcement are separated for easy adjustment on site during the assembly process. The last stage is carried out by arranging all the reinforcement parts directly on site without remanufacturing, until all elements are ready to be installed following the most appropriate method for field conditions.

7. Checking
   After the installation of the beam reinforcement is declared complete, a quality inspection is carried out on the reinforcement. The components examined include the diameter of the reinforcement, the number of main rods, the distance between the reinforcements, the number of stingers, wire bonds, and the checking of concrete formwork.
8. Beam Casting Process
   The stages of block casting generally include:
   a. Clean the area to be cast using *an air compressor* until it is sure to be free of dirt.
   b. *The bucket* is washed or watered first to remove dust and concrete residue from previous casting. After that, a *slump test* basket was prepared for sampling supervised by *engineers* and the supervisory team.
   c. If the area is ready, the casting process can begin.
   d. Concrete sampling is carried out at the same time as the casting process. The fresh concrete that comes out of the truck is accommodated with *a bucket* which is then lifted using *a tower crane*.
   e. After the *bucket* arrives at the foundry site, the officer opens the *bucket* valve to drain fresh concrete to the area to be cast.
   f. Workers then level the concrete on the beams, and the concrete surface is arranged using *scrub*. After leveling, the elevation is checked again using *a waterpass*. The *vibrator* operator then inserts the tool into the concrete at a depth of 5–10 minutes in each section to avoid the formation of air cavities and ensure that the quality of the concrete remains good. After all parts are filled, the surface of the beam is smoothed using long wood while still paying attention to the planned height level.

9. Formwork Disassembly
   Formwork can begin to be disassembled after 7 days of age from the time casting is performed.
10. Care/curring
   After the casting is completed, a concrete treatment process is carried out to maintain its quality. This treatment is carried out by watering the concrete surface periodically for approximately one week.

Productivity

In general, in the implementation of construction projects, productivity is not paid much attention, even though productivity is one of the factors for the success of a project work, because the speed and slowness of project work depend on the productivity planning. According to Pilcher (1992), productivity is the value of a production work. Productivity in a more general sense can be defined as a comparison between the output, volume of activities, and inputs of tools and labor. Equipment is all the tools used during the series of project activities, Simple equipment is a tool that is run by human power, whereas modern equipment is driven by the help of machines. In general, the use of modern equipment is able to produce a higher level of productivity compared to simple tools. This is due to the ability of the machine to work more optimally without experiencing a decrease in power, so that work can be completed faster and more efficiently.

The productivity formula can be seen in the Equations

$$Produktivitas = \frac{hasil\ kegiatan\ (output)}{masukan\ (input)}$$

According to Wignjosoebroto (1995), labor productivity is a comparison or *ratio* between the amount of output and the amount of input. The output in question is the result of the work produced, while the input includes all resources used and expressed in monetary units.
The productivity formula can be formulated as:

$$Produktivitas = \frac{Efektivitas\ menhasilkan\ output}{Efisiensi\ mengunakan\ input} \quad .$$

RESEARCH METHODOLOGY

Research Stage

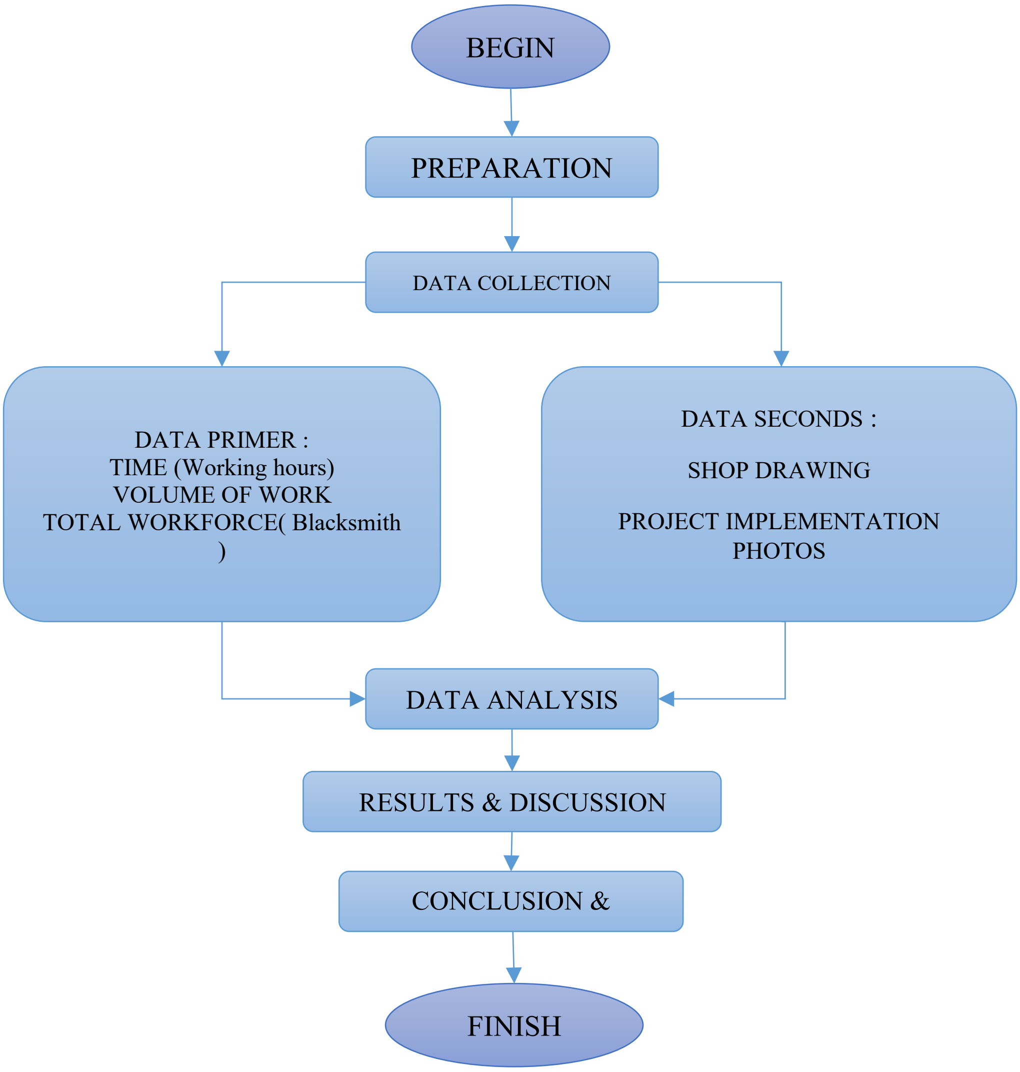

Figure 1 - Flowchart.

ANALYSIS AND DISCUSSION

Work Productivity Analysis Reinforced concrete beams

In obtaining the results of productivity analysis on reinforced concrete block work, measurements are carried out directly at the project site during the activity. This analysis focuses on ironing work or the installation of reinforcement of B1 Beams (40×80) with an elevation of 3.90 m. Observations are made at the beginning and end of working hours.

The implementation of the work follows the standard working hours that have been set by the project, which is one working day for 7 hours, starting at 07.00–11.00 WIB. Furthermore, there is a break period at 11.00–13.00 WIB and work is resumed until 16.00 WIB. Exceptions apply to foundry work as it is generally done at night. On average, the casting work takes place at night around 21.00 until it is finished, adjusting the number of workers that has been set.

4.2.1 Volume Observation

Data on the volume of ironing/installation of beam reinforcement work was obtained from direct observation in the field. The method used is to measure the length of the repetition of the blocks that have been worked. From the observations and measurements that have been carried out at the time of the research, the following measurement data was obtained:

Table 4. 1 Beam reinforcement length observation data

Observation to-	Types of beams	Repetition length	
		Clean	Kotor
		mm	mm
1	B1(40×80)	7800	10450
2	B1(40×80)	7800	5850
3	B1(40×80)	10300	13580
4	B1(40×80)	10300	7720
5	B1(40×80)	7800	10450
6	B1(40×80)	7800	5850
7	B1(40×80)	10300	13580
8	B1(40×80)	10300	7720

Source : Processed researcher

After obtaining the length data of the reinforcement that has been installed, it is then calculated so that it becomes the volume of the beam ironing work. Details of the ironing of the B1 beam can be seen in the image below

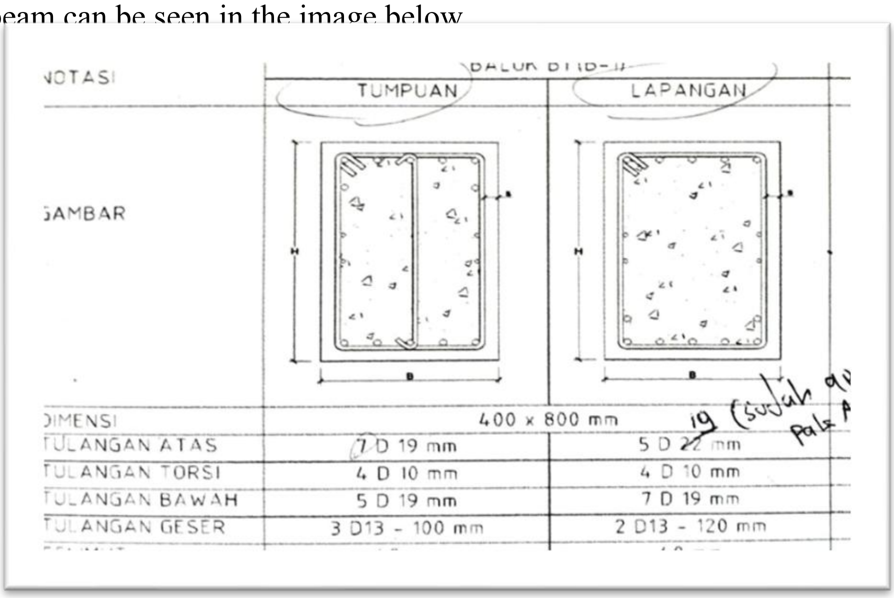

Figure 4. 1 B1 Beam Ironing Details

Based on the ironing details above, the assembly of the beam reinforcement is used upper reinforcement with an iron base of 7 threads with a diameter of 19 mm and an iron field of 5 threads with a diameter of 19 mm. In the torque reinforcement, 4-thread iron with a diameter of 10 mm is used for the base and field. The bottom reinforcement is used 5-thread iron with a diameter of 19 mm on the pedestal and a 7-thread iron with a diameter of 19 mm on the field. 3ft sliding reinforcement with 13 mm diameter threaded iron with each 100 mm distance on the pedestal and 2 feet sliding reinforcement with 13 mm diameter threaded iron every 100 mm distance. The blanket of concrete beams is 40 mm.

The calculation of the volume of reinforcement on the beam can be calculated in the following way:

The calculation of beam ironing was reviewed on type B1 (40×80) beams with the following data:

Beam width : 0,4 m
Beam height : 0,8 m
10D threaded iron : 0.617 kg/m
13D threaded iron : 1,042 kg/m

19D threaded iron : 2,226 kg/m

Reinforcement Top left focus	7D19 mm
Reinforcement Lower right focus	5D19 mm
Reinforcement Upper Field	5D19 mm
Lower Field Reinforcement	7D19 mm
Upper right focus reinforcement	7D19 mm
Reinforcement Lower left focus	5D19 mm
Shrinkage reinforcement	4D10 mm
Focus shear reinforcement	3 khaki D13-100 mm
Field shear reinforcement	2 khaki D13-120 mm

Day 1 Observation

Note: The gross length of the repetition that has been done is 10.45 and the net length is 7.8 m

a) Main Reinforcement over D19

- Panjang :
  Gross length of reinforcement + (Pass length 28db) + (Channel length 18db) (Bending diameter 4db) + (End length 12db)
  = 10,45 + (28 x 0,019) + (18 x 0,019) + (4 x 0,019) + (12 x 0,019)
  = 10,45 + 0,532 + 0,342 + 0,076 + 0,228
  = 11,628 m
- Number of Reinforcement : 5 nos
- Total reinforcement weight:
  Length x Number of reinforcement x Weight of iron
  = 11,628 x 5 x 2,226
  = 129.41964 kg

b) Main Reinforcement under D19

- Panjang :
  Gross length of reinforcement + (Pass length 46db) + (Channel length 35db) + (Bending diameter 4db) + (End length 12db)
  = 10,45 + (46 x 0,019) + (35 x 0,019) + (4 x 0,019) + (12 x 0,019)
  = 10,45 + 0,874 + 0,665 + 0,076 + 0,228
  = 12,293 m
- Number of Reinforcement : 5 nos
- Total reinforcement weight:
  Length x Number of reinforcement x Weight of iron
  = 12,293 x 5 x 2,226
  = 136.82109 kg

c) Upper left focus reinforcement D19

- Panjang :
  (Beam support length 1/4 span) + (Bending diameter 4db) + (End length 12 db)
  = (1,95) + (4 x 0,019) + (12 x 0,019)
  = 1,95 + 0,076 + 0,228
  = 2,254 m
- Number of Reinforcement : 2 nos
- Total reinforcement weight:
  Length x Number of reinforcement x Weight of iron
  = 2,254 x 2 x 2,226
  = 10.034808 kg

d) D19 basement reinforcement

- Panjang :

(Beam length 1/2 span)
= 3,9 m

- Number of Reinforcement : 2 nos
- Total reinforcement weight:
  Length x Number of reinforcement x Weight of iron
  = 3,9 x 2 x 2,226
  = 17.3628 kg

e) Upper right focus reinforcement D19

- Panjang :
  (Beam support length 1/4 span) + (Bending diameter 4db) + (End length 12db)
  = (1,95) + (4 x 0,019) + (12 x 0,019)
  = 2,254 m
- Number of Reinforcement : 2 nos
- Total reinforcement weight:
  Length x Number of reinforcement x Weight of iron
  = 2,254 x 2 x 2,226
  = 10.034808 kg

f) Focus Sliding Reinforcement

3D13-100 mm

- Length of Shingles:
  Beam circumference length - (Concrete blanket) + (Bending diameter 4ds) + (end length 8ds)
  = ((0.8 + 0.4) x 2) - (0.04 x 4 sides) + (4 x 0.013 x 2 sides) + (8 x 0.013 x 2 sides)
  = 2,4 - 0,16 + 0,104 + 0,208
  = 2,552 m
- Number of Reinforcements :
  (Beam focus length)/ installation distance
  = 1,95 / 0,1
  = 19.5 ~ 19 nos
- Weight of Reinforcement :
  Length x Number of reinforcement x Weight of iron
  = 2,552 x 19 x 1,042
  = 50.524496 kg
- Unilateral length of the beam
  (Beam height) – (concrete blanket) + (Bend diameter 4ds) + (End length 6ds)
  = 0.8 – (0.04 x 2 sides) + (4 x 0.013 x 2 sides) + (6 x 0.013 x 2 sides)
  = 0,8 – 0,08 + 0,104 + 0,156
  = 0.98 m
- Unilateral reinforcement amount
  (Beam focus length)/ installation distance
  = 1,95 / 0,1
  = 19.5 ~ 19 nos
- Unilateral reinforcement weight
  Length x Number of reinforcement x Weight of iron
  = 0.98 x 19 x 1.042
  = 19.40204 kg
- Total weight
  = (50.524496 + 19.40204) x 2
  = 139.8629792 kg

g) Reinforcement Shear field

2D13-120 mm

- Length of Shingles:
  Beam circumference length - (Concrete blanket) + (Bend diameter 4ds) + (End length 8ds)
  = ((0.8 + 0.4) x 2) - (0.04 x 4 sides) + (4 x 0.013 x 2 sides) + (8 x 0.013 x 2 sides)
  = 2.4 - 0.16 + 0.104 + 0.208
  = 2,552 m
- Number of Reinforcements :
  (Beam length 12 spans)/ installation distance
  = 3.9 / 0.12
  = 32.5~32 nos
- Total Weight :
  Length x Number of reinforcement x Weight of iron
  = 2,552 x 32 x 1,042
  = 85.093888 kg

h) Torque reinforcement D10

- Panjang :
  Beam length + (Bending diameter 4db) + (End length 4db)
  = 7.8 + (4 x 0.01 x 2 sides) + (4 x 0.01 x 2 sides)
  = 7,8 + 0,08 + 0,08
  = 7,96 m
- Number of Reinforcement : 4 nos
- Total reinforcement weight:
  Length x Number of reinforcement x Weight of iron
  = 7,96 x 4 x 0,617
  = 19.64528 kg

So the volume of installation of beam reinforcement on the first day is:
V = 129.41964 kg + 136.82109 kg + 10.034808 kg + 17.3628 kg + 10.034808 kg + 139.8629792 kg + 85.093888 kg + 19.64528 kg
V = 548.2752932 kg

Calculation of Productivity of reinforcement installation work

Based on previous volume observations, data on output volume, working hours and number of craftsmen in ironing work were obtained. For the results of observations in the field, it can be seen in table 2

Table 2 Observation data of repeat work

Observation of the day	Working hours	Output volume (kg)	Number of Builders
1	7	548,275	4
2	7	445,879	4
3	7	746,104	4
4	7	615,994	4
5	7	621,872	4
6	7	375,943	4
7	7	842,127	4
8	7	520,305	4

From the data obtained, the productivity of the working group in the 1st observation was calculated as follows:
Known:
Number of working hours per day = 7 hours
Volume of work = 548,275

Workgroup productivity = Out put (work volume)in put (working hours)
= 548,2757
= 78,325 kg/jam

Based on the results of the first day's observation, the productivity of the working group was recorded at **78.325 kg/hour**. The calculation on the second to eighth day uses the same procedure as the first day. The results of the productivity analysis for each day can be seen in Table 3 which contains the productivity data of the working group.

Table 3 Working Group Productivity Data

Observation On the day of the	Working hours	Volume of Work (kg)	Productivity of Ex. Working (kg/h)
1	7	548,275	78,325
2	7	445,879	63,697
3	7	746,104	106,586
4	7	615,994	87,999
5	7	621,872	88,839
6	7	375,943	53,706
7	7	842,127	120,309
8	7	520,305	74,329
Average			84,223

The calculation of worker productivity is calculated by dividing the total volume of work by the number of workers involved. The following are the results of the calculation of blacksmith productivity in kg/OH units based on the data of the first day.
Known:
Number of blacksmiths = 4 people
Vol. of work = 548,275 kg
Handyman productivity = Volume of Work Number of Workers
= 548,2754
= 137,06875 kg/OH
From these calculations, it was obtained that the productivity of blacksmiths on the first day was **137,069 kg/OH.** The calculation of productivity in the following days (day 2 to day 8) can be seen in Table 4

Table 4 Blacksmith Productivity Data

Observation Day	Number of Builders (orang)	Volume of Work (kg)	Handyman Productivity (kg/OH)
1	4	548,275	137,069
2	4	445,879	111,470
3	4	746,104	186,526
4	4	615,994	153,998
5	4	621,872	155,468
6	4	375,943	93,986
7	4	842,127	210,532
8	4	520,305	130,076
Average			147,390

Table 4.5 shows the blacksmith's productivity on the first day of 137,069 kg/OH. On the 2nd day it was 111,470 kg/OH, the 3rd day was 186,526 kg/OH, the 4th day was 153,998 kg/OH, the 5th

day was 155,468 kg/OH, the 6th day was 93,986 kg/OH, the 7th day was 210,532 kg/OH, the 8th day was 130,076 kg/OH.

Productivity Calculation of PUPR Regulation No. 1 of 2022

Regulation of the Minister of Public Works and Public Housing (Permen PUPR) No. 1 of 2022 contains provisions regarding unit price analysis used as a reference in assessing the productivity of work in the field.

Table 4. 5 100 kg repetition with Plain Iron or Fin Iron

No	Description	Code	Unit	Coeficin	Unit Price (Rp)	Total Price (Rp)
A	TENAGA					
	Worker	L.01	OH	0,7		
	Blacksmith	L.02	OH	0,7		
	Head Builder	L.03	OH	0,07		
	Foreman	L.04	OH	0,04		
				Total Labor Price		
B	MATERIAL					
	Concrete Iron		Kg	105		
	Bendrat Wire		Kg	1,5		
				Total Material Price		
C	EQUIPMENT					
				Total Equipment Price		
D	Total (A+B+C)					
And	General costs and profits (overhead & profit) maximum of 15 %					
F	Unit Price of Work (D+E)					

Source : Permen PUPR No. 1 of 2022

Based on the data above, the calculation of productivity based on the Minister of PUPR Regulation No. 1 of 2022 is calculated as follows:

Handyman productivity = Volume of Work blacksmith coefficient

= 1000,7

= 142,857 kg/OH

Thus, the productivity value of blacksmiths based on the Ministerial Regulation of PUPR No. 1 of 2022 is **142,857 kg/OH.**

Comparison of Field Productivity with the Minister of Public Works and Public Works Regulation No. 1 of 2022

The results of the comparison of the average productivity of the field and the Minister of PUPR No. 1 of 2022 can be seen in the table below.

Table 6 Recapitulation of Repeat/ironing Productivity

Observation Day	Field Productivity	Candy Productivity PUPR No. 1 of 2002
1	137,069	142,857
2	111,470	142,857
3	186,526	142,857
4	153,998	142,857
5	155,468	142,857
6	93,986	142,857
7	210,532	142,857
8	130,076	142,857
Average	147,390	142,857

Based on the results of the previous recapitulation, a comparison was made between the productivity of workers in the field and the productivity standards listed in the Minister of PUPR Regulation No. 1 of 2022. The calculation of the comparison is as follows:

Comparison of Fields and PUPR Candy = Field ProductivityPUPR Candy Productivity
= 137,069142,857
= 0.959 times

The comparison between the average productivity of work in the field and productivity according to the Minister of PUPR No. 1 of 2022 can be seen in the following table:

Table 7 Results of Field Productivity Comparison & PUPR Candy

Day	Field Productivity	Candy Productivity PUPR No. 1 of 2002	Productivity Comparison Field & PUPR Candy
1	137,069	142,857	0,959
2	111,470	142,857	0,780
3	186,526	142,857	1,305
4	153,998	142,857	1,077
5	155,468	142,857	1,088
6	93,986	142,857	0,657
7	210,532	142,857	1,473
8	130,076	142,857	0,910
Average	147,390	142,857	1,031

CONCLUSION

1. The reinforced concrete block work in the JIIPE Gresik Mosque-BKMS construction project was carried out using conventional methods, including the stages of preparation, measurement, ironing work, installation of formwork, checking, casting process, dismantling of formwork, and treatment (*curing*). The entire series of works is carried out on the project site with the support of specific tools. Overall, the implementation of the B1 Beam (40×80) work at an elevation of ±3.90 m went well and followed the planned procedures.
2. Based on the results of the research analysis, the average productivity of the working group reached **84,223 kg/hour**, while the average productivity value of labor (blacksmiths) was **147,390 kg/OH** for the installation of reinforced beam reinforcement work in the construction project of the JIIPE Gresik Mosque-BKMS.

3. The result of the productivity calculation according to the Minister of PUPR Regulation No. 1 of 2022 for blacksmith labor is **142,857 kg/OH.** When this value is compared to the average field productivity, a ratio of **1.031 times** is obtained. Thus, labor productivity in the field is higher than the standards listed in the Ministerial Regulation of PUPR No. 1 of 2022, so it can be concluded that the performance of workers in the field has met or even exceeded the reference value.

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