

FINAL PROJECT

**LABOUR PRODUCTIVITY OF THE STEEL
STRUCTURE USING WORK SAMPLING METHOD
(STUDY CASE PROJECT CONSTRUCTION OF GELANGGANG
INOVASI DAN KREATIVITAS UGM YOGYAKARTA)**

**A Thesis Presented to the Universitas Islam Indonesia as Partial Fulfilment of
the Requirements for the Bachelor Degree of Civil Engineering**



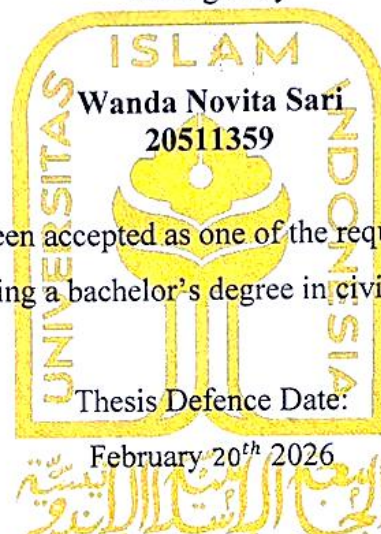
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UNIVERSITAS ISLAM INDONESIA
2026**

FINAL PROJECT

LABOUR PRODUCTIVITY OF THE STEEL STRUCTURE USING WORK SAMPLING METHOD (STUDY CASE PROJECT CONSTRUCTION OF GELANGGANG INOVASI DAN KREATIVITAS UGM YOGYAKARTA)

Arranged by



Has been accepted as one of the requirements
for obtaining a bachelor's degree in civil engineering

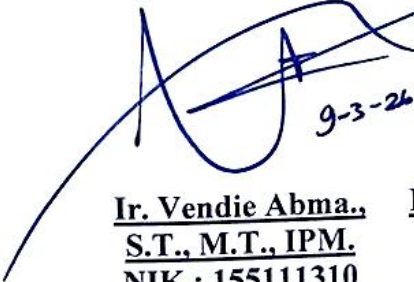
Thesis Defence Date:

February 20th 2026

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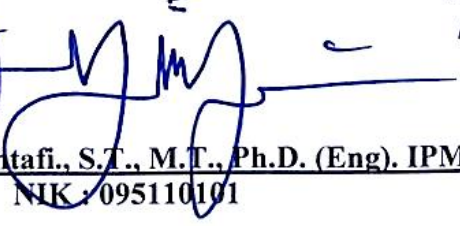

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PLAGIARISM FREE STATEMENT

This Final Project Report is submitted as a partial fulfilment of the requirements for obtaining the bachelor's degree in the Undergraduate Program of Civil Engineering, Faculty of Civil Engineering and Planning, Universitas Islam Indonesia. It is hereby declared that this report is entirely the original work of the author. All sources of information, data, statements, or ideas derived from the work of others have been properly acknowledged and cited in accordance with prevailing academic standards, regulations, and the ethics of scientific writing. Should it be proven at any time that this report, in whole or in part, does not constitute original work or contains elements of plagiarism, full responsibility shall be borne accordingly, and any academic sanctions imposed in accordance with applicable laws and regulations, including the revocation of the academic degree conferred, shall be accepted.

Yogyakarta, February 20th 2026

Statement by,



Wanda Novita Sari

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PREFACE

The author would like to thank Allah SWT for the guidance to complete the Final Project entitled “Labour Productivity of the Steel Structure Using Work Sampling Method” This Final Project is one of the academic requirements for completing the Civil Engineering Undergraduate Program, Faculty of Civil Engineering and Planning, Universitas Islam Indonesia, Yogyakarta. In preparing this Final Project, the author faced several obstacles, but thanks to suggestions, criticism, and encouragement from various people, this Final Project was successfully completed.

1. Ir. Yunalia Muntafi, S.T., M.T., Ph.D. (Eng)., IPM., as Head of the Civil Engineering Study Program, Faculty of Civil Engineering and Planning, Universitas Islam Indonesia, Yogyakarta.
2. Ir. Vendie Abma, S.T., M.T., IPM., as supervisor for the Final Project, who always took the time to discuss, provide valuable knowledge, and guide this Final Project to completion.
3. Ir. Tri Nugroho Sulistyantoro, S.T., M.T., was willing to devote his time during examinations and provided many valuable suggestions for the improvement of this research.
4. Rizki Budiman, S.T., M.T., was willing to devote his time during examinations and provided many valuable suggestions for the improvement of this research.
5. Astriana Hardawati, S.T., M.Eng. My best DPA deepest gratitude to my academic supervisor for her invaluable guidance, direction, and continuous support throughout the entire the study process.

Finally, the author hopes that this Final Project can provide knowledge, serve as a useful reference, and assist readers. Although this research still has limitations, the author hopes it can open the door for further meaningful and in-depth studies, particularly related to the implementation of Civil Engineering practices in Indonesia.

DEDICATION PAGE

In preparing this Final Project, the author encountered many challenges, but with the continuous support from various parties, the author was able to complete this work successfully. With deep gratitude, the author dedicates this Final Project to:

1. My self for stay strong, patient, and determined in completing this long and meaningful journey.
2. My one and only best husband in the world Rizqy Adam Sambodo., S.T thank you for always support and agree with my all decision.
3. My parent, who have given endless prayers.
4. My dear siblings, who have always supported and prayed for me throughout this journey.
5. All my friend, and individuals who have provided encouragement, guidance, and support, either directly or indirectly.

Finally, the author hopes that this Final Project can provide education and assist readers. This research has limitations and shortcomings the author hopes that its content can open more meaningful and in-depth discussions that contribute to the implementation of civil engineering in Indonesia.

ABSTRACT

The construction industry requires effective labour management to ensure project efficiency and performance, particularly in structural steel construction. This study aims to analyse labour productivity in the installation of the Joglo steel roof structure at Universitas Gadjah Mada using the work sampling method and to compare the observed productivity with the labour productivity standards specified in the Circular Letter of the Director General of Construction Development Number 182/SE/DK/2025 (SE DJB No 182/SE/Dk/2025). The study was conducted over 12 days of observation involving five labours consisting of two welders and three helpers. The data were collected using the Five Minutes Rate method, resulting in a total of 5.760 observation data points obtained from (12 days $\times$ 96 samples $\times$ 5 labourers). The results show that the productivity control limits were within an average Lower Control Limit (LCL) of 0,58 and an Upper Control Limit (UCL) of 0,97 with an average field productive of 0,78. Based on the work sampling analysis, the calculated normal time was 3,74 minutes/kg and the standard time was 4,30 minutes/kg. The average labour productivity reached 43,63 kg/day for welders and 29,08 kg/day for helpers. Furthermore, the data sufficiency test produced a value of 451,28. Indicating that the number of observations was adequate and statistically representative. When compared with the productivity standards (SE DJB No 182/SE/Dk/2025), the helper productivity rate of 29,08 kg/day slightly exceeds the benchmark value of 26,67 kg/day. In contrast, the field productivity of welders, recorded at 43,63 kg/day, is significantly lower than the standard value of 80 kg/day. These differences indicate that labour productivity in the field may be influenced by several factors, including labour skill levels, work complexity, environmental and weather conditions, material availability, and managerial supervision. The findings of this study provide empirical evidence of actual field productivity and can serve as a reference for evaluating labour efficiency and improving workforce management in steel roof structure construction projects.

Keywords : Labour productivity, Five Minutes Rate of Work sampling, Steel structure.

TABLE OF CONTENTS

LABOUR PRODUCTIVITY OF THE STEEL STRUCTURE USING WORK SAMPLING METHOD	Error! Bookmark not defined.
PLAGIARISM FREE STATEMENT	Error! Bookmark not defined.
PREFACE	iii
DEDICATION PAGE	iv
ABSTRACT	v
TABLE OF CONTENTS	vi
LIST OF TABLES	viii
LIST OF FIGURES	ix
LIST OF APPENDICES	x
CHAPTER I INTRODUCTION	1
1.1 Background	1
1.2 Problem Statement	3
1.3 Research Objectives	4
1.4 Significance of Research	4
1.5 Research Limitations	4
CHAPTER II LITERATURE REVIEW	5
2.1 Previous Research	5
2.2 Conduct Research	7
CHAPTER III THEORETICAL BASIS	11
3.1 Project Construction	11
3.2 Construction Management	11
3.3 Productivity	14
3.4 Work Sampling	16
3.5 The Five Minutes Rating	18
3.6 Standard and Implementation Guidelines	24
3.7 Roof Truss	26
3.8 Steel Structure	26

CHAPTER IV METHODOLOGY	28
4.1 Research Method	28
4.2 Research Location	28
4.3 Research Object and Subject	29
4.4 Joglo Roof Structure	29
4.5 Types of Data	31
4.6 Data Collection	32
4.7 Research Stages	36
4.8 Flowchart	36
CHAPTER V ANALYSIS DISCUSSION	38
5.1 Observation Object Analysis	38
5.2 Data Analysis	38
5.2.1 Data Labour Observation	38
5.2.2 Data Uniformity Test	44
5.2.3 Data Sufficiency Test	46
5.2.4 Calculate Required Observation	49
5.2.5 Calculate Labours Productivity	51
5.3 Productivity Calculations According to SE DJB No 182/SE/Dk/2025	52
5.4 Comparison of Labour Productivity Between Field Productivity and Productivity of SE DJB No 182/SE/Dk/2025	53
5.5 Discussion	53
CHAPTER VI	57
CONCLUSION AND RECOMMENDATION	57
6.1 Conclusion	57
6.2 Recommendation	57
REFERENCES	58
APPENDICES	60

LIST OF TABLES

Table 2.1 Previous Research Result	7
Table 3.1 Standard Labour Output and References Work Item	25
Tabel 4. 1 Form Observation Data of Labour Productivity in the Field	33
Table 5.1 Observation Data of Labour Productivity in the Field Day 1	39
Table 5.2 Total Observation Frequency	43
Table 5.3 Recapitulation of The Uniformity Calculation	46
Table 5.4 Recapitulation of The Data Sufficiency Test	48
Table 5.5 Total Unit Production Observation	50

LIST OF FIGURES

Figure 3.1 Performance Rating Table (Westinghouse)	22
Figure 3.2 Steel Structure	27
Figure 4.1 Project Location of Gelanggang Inovasi Kreativitas Building	28
Figure 4.2 Project Map of Gelanggang Inovasi Kreativitas Building	29
Figure 4.3 3D Isometric Steel Roof	30
Figure 4.4 Framing Axis Line Limasan	30
Figure 4.5 Roof Framing Plan	31
Figure 4.6 Flowchart of Research	37
Figure 5.1 Control Graph Labours	54
Figure 5.2 Graphic Daily Field Production	55
Figure 5.3 Comparison the productivity of steel roof frame installers ccording to SE DJB No 182/SE/Dk/2025	56

LIST OF APPENDICES

Appendix 1 Observation Data Labour Productivity in the Field for Day 1	61
Appendix 2 Observation Data Labour Productivity in the Field for Day 2	64
Appendix 3 Observation Data Labour Productivity in the Field for Day 3	67
Appendix 4 Observation Data Labour Productivity in the Field for Day 4	70
Appendix 5 Observation Data Labour Productivity in the Field for Day 5	73
Appendix 6 Observation Data Labour Productivity in the Field for Day 6	76
Appendix 7 Observation Data Labour Productivity in the Field for Day 7	79
Appendix 8 Observation Data Labour Productivity in the Field for Day 8	82
Appendix 9 Observation Data Labour Productivity in the Field for Day 9	85
Appendix 10 Observation Data Labour Productivity in the Field for Day 10	88
Appendix 11 Observation Data Labour Productivity in the Field for Day 11	91
Appendix 12 Observation Data Labour Productivity in the Field for Day 12	94
Appendix 13 Documentation Data Processing	97
Appendix 14 Technical Drawing of Joglo Roof	99
Appendix 15 Technical Drawing of Joglo Roof	100
Appendix 16 Technical Drawing of Joglo Roof	101

CHAPTER I

INTRODUCTION

1.1 Background

The construction industry plays a significant role in national economic development, particularly in supporting infrastructure growth and public facilities. The successful implementation of construction projects is largely determined by the effective management of resources, including labour, materials, equipment, time, and cost. Among these resources, labour is considered one of the most critical factors, as construction activities are predominantly labour intensive and highly dependent on human performance. According to Heizer et al. (2014), effective resource management is essential to ensure project objectives are achieved within predetermined time and cost constraints.

Labour productivity is widely recognized as a key indicator of efficiency and effectiveness in construction projects. Productivity is generally defined as the ratio between output and input, where output represents the quantity of work produced and input refers to the resources utilized, particularly labour time (Budiasih et al., 2023). In construction contexts, labour productivity reflects the ability of labours to complete assigned tasks within a certain period while maintaining required quality standards. Yarahmadi et al. (2023) emphasize that labour productivity significantly influences project duration and overall performance, while Karima et al. (2020) explain that productivity measurement is fundamental in evaluating efficiency in construction operations.

In Indonesia, labour productivity standards for construction cost estimation are regulated through the Circular Letter of the Directorate General of Construction Development Number 182/SE/DK/2025 concerning Procedures for Preparing Cost Estimates for Construction Works in the Public Works Sector. This regulation provides standardized labour coefficients that serve as benchmarks for planning and budgeting purposes. However, field productivity may differ from these standards due to various influencing factors. Afrian et al. (2024) identify several factors

affecting labour productivity, including labour skills, wages, experience, education, material availability, weather conditions, supervision quality, and managerial capacity. Similarly, Alsa (2023) states that labour productivity is closely related to work effectiveness and optimal utilization of working time. One of the critical construction activities that requires careful productivity evaluation is steel structure work, particularly roof truss installation. Steel structures are increasingly used in modern construction due to their structural strength, durability, and efficiency. Oktarina (2015) explains that roof truss structures function as the primary load-bearing system of a roof, distributing vertical and horizontal loads to supporting structural elements. The Joglo style roof, which has distinctive architectural characteristics and structural complexity, requires precise installation processes and coordinated teamwork between welders and helpers. Inefficiencies in labour performance in such structural work can result in delays, cost overruns, and reduced project performance.

To measure labour productivity accurately in dynamic construction environments, appropriate analytical methods are required. One widely used technique is the work sampling method. Yuanto et al. (2018) describe work sampling as a statistical technique used to measure productive and non-productive activities through periodic observations. Oglesby, Parker, and Howell (1989) further explain that work sampling is effective for estimating labour productivity without continuous observation, making it suitable for construction environments where activities are complex and variable. Several previous studies have applied the work sampling method to evaluate labour productivity in construction projects. Rizaldi (2021) compared work sampling with historical experience methods in masonry work and found differences in statistical adequacy and practical applicability. Nadhim et al. (2023) analysed workload and productivity using work sampling combined with NASA-TLX and concluded that physical workload significantly influences performance levels. Firda et al. (2023) examined labour productivity in pile installation work and identified supervision and teamwork as significant factors affecting labour utilization rates. Wicaksono et al. (2023) analysed steel fabrication productivity and demonstrated variations in output based

on work type. Additionally, Walakutty et al. (2024) investigated bricklaying and plastering productivity using work sampling and reported differing labour utilization rates across tasks. Although previous studies have examined labour productivity in various construction activities, limited research has specifically analysed labour productivity in Joglo roof steel structure installation and directly compared field productivity results with the standardized labour coefficients established in SE DJB No. 182/SE/DK/2025. Therefore, a research gap remains in understanding the extent to which actual field performance aligns with national productivity benchmarks in this specific type of structural work.

Based on these considerations, this study aims to analyse labour productivity in the installation of Joglo roof steel structures at the Gelanggang Inovasi dan Kreativitas (GIK) Building project, Universitas Gadjah Mada, using the work sampling method. The results of this research are expected to provide empirical evidence regarding actual labour efficiency in the field and to evaluate its conformity with established national standards. Furthermore, the findings may contribute to improving labour management strategies and enhancing productivity in similar construction projects.

1.2 Problem Statement

Based on the background described, then the problem being researched can be formulated as follows.

1. What is the labour productivity of the roof steel structure using work sampling method?
2. How does the compare of labour productivity with the Circular Letter of The Director General of Construction Development Number 182/SE/DK/2025 regarding procedure for preparing cost estimates for construction works in the public work sector?

1.3 Research Objectives

Based on the exposure to the background above, the objectives of this study are:

1. To find out labour productivity roof with work sampling method on steel structures roof of Joglo Gelanggang Inovasi dan Kreatif (GIK).
2. To find out the comparison of steel structure labour productivity in the field with the benchmark of Circular Letter of the Directorate General of Customs and Excise Number 182/SE/DK/2025 (SE DJB No 182/SE/Dk/2025) regarding procedure for preparing cost estimates for construction works in the public work sector.

1.4 Significance of Research

Some of advantages expected from this research are as follows:

1. For Researchers
This research is expected to provide perceptions in building construction work the labour productivity and how company resource are allocated can be known.
2. For contractors or implementers
This research may be provided information on factors that influence labour productivity in building construction projects so it can assist project managers to optimize labour resources and plan more effective strategies for steel structure work.

1.5 Research Limitations

To conform to the expected goals, the limitations of the problem in this study are as follows:

1. Overall data collection from steel structure work in the Joglo Zone in *Gelanggang Kreativitas dan Inovasi* (GIK) building project in Gadjah Mada University Yogyakarta.
2. Observation on the implementation of the installation of steel structures as *Joglo* roofs.
3. The method used to analyse labour productivity uses the Work Sampling Method.

CHAPTER II

LITERATURE REVIEW

2.1 Previous Research

Analysis of Labour Productivity on Masonry Work with Work Sampling Method and Historical Experience Method. Based on the research that has been conducted and the results of the analysis and discussion, it can be concluded that the work sampling method obtained productivity results of 6,055 m³/day, but this method did not pass the data uniformity and adequacy test. In the productivity calculation, only one work group can be calculated. From the results of this study, the productivity value of the historical experience method of the craftsman was 0,443 m³/hour/person and the labour 0,098 m³/hour/person. The method that can be applied is the historical experience method because this method is very practical (Rizaldi, 2021).

Research conducted by Nadhim et al. (2023), entitled Physical and Metal Workload Analysis Using Work Sampling Method and NASA-TLX as an Effort to Increase Work Productivity at PT. Putra Sulung Makmur Metal Castindo, found that the physical workload of production operators in the pump body section, measured using the Work Sampling method, reached 74%, which is close to the maximum threshold of 100%. Furthermore, the NASA-TLX analysis indicated that the most dominant factor influencing mental workload was effort, with a score of 2454.

Similar research was conducted by Firda (2023) in a study entitled Labour Productivity Using Work Sampling Method (Pile Installation Work). The analysis measured productivity through the Labour Utilization Rate (LUR) and the daily labour coefficient of bore pile construction. This study also examined factors influencing LUR using a questionnaire. The work sampling results showed that the overall LUR of the bore pile construction project was 73,45%, with a high productivity rate of 6.404 m²/hour/person. The highest productivity across tasks occurred on Tuesday. Furthermore, t-test analysis revealed that factors such as

control and supervision, teamwork, and leadership significance affected labour productivity at the 95% confidence level, while materials and equipment, rework, information, attendance, scheduling, motivation, morale, behaviour, skills, and labour substitution showed no significance effect. Wicaksono et al. (2023) conducted a study entitled Labour Productivity Analysis in Steel Fabrication Work in Majalengka Steel Fabrication. Using the work study method and field observations, this research measured productivity values based on work type. The findings showed that plate marking yielded 563,25 kg/person/day and WF 886,47 kg/person/day, plate cutting reached 891,85 kg/person/day and WF 259,53 kg/person/day, while assembly productivity was 282,43 kg/person/day. A related study by Walakutty et al. (2024), entitled Analysis of Labour Productivity with the Work Sampling Method in Office Building Construction in Maluku Province, examined bricklaying and plastering activities. The findings showed that the productivity of bricklaying was 1.680 m²/hour/person with a Labour Utilization Rate (LUR) of 43,60%, while plastering work achieved 25,65 m²/hour/person with an LUR of 36,20%.

2.2 Conduct Research

Literature reviews regarding the research that has been carried out are summarized in Table 2.1.

Table 2. 1 Previous Research Result

Aspect	Previous Research				
	Rizaldi (2021)	Nadhim et al. (2023)	Firda et al. (2023)	Wicaksono et al. (2023)	Walakutty et al. (2024)
Title	Analysis of Labour Productivity on Masonry Work with Work Sampling Method and Historical Experience Method.	Physical and Metal Workload Analysis Using Work Sampling Method and NASA-TLX as an Effort to Increase Work Productivity at PT. Putra Sulung Metal Castindo.	Labour Productivity Using Work Sampling Method (Pile Installation Work).	Labour Productivity Analysis in Steel Fabrication Work in Majalengka Steel Fabrication	Analysis of Labour Productivity with The Work Sampling Method in Office Building Construction in Maluku Province
Locations	Road and Bridge Construction Project in Diro, Sleman, Yogyakarta.	PT. Putra Sulung Metal Castindo, Central Java.	The Fame City Walk Building Project in Palembang.	Steel Fabrication in Majalengka.	Construction Project at Jl. Laksadia Leo Watimena, Nania, Bagula, Ambon Maluku.

Table 2.1 Previous Research Result (continued)

Aspect	Previous Research				
	Rizaldi (2021)	Nadhim et al. (2023)	Firda et al. (2023)	Wicaksono et al. (2023)	Walakutty et al. (2024)
Objectives	Knowing the labour productivity in stone masonry using the work sampling method and historical experience method. Also knowing the methods that can be applied in this study.	Analysing the level of physical workload to increase work productivity and analysing the level of metal workload as an effort to increase work productivity at PT. Putra Sulung Makmur Metal Castindo	Assist contractors in improving project planning. In addition, the data can also be used as a reference to obtain a budget, so that a reasonable price is obtained to be issued as wages for construction labours, according to current conditions and circumstances.	Collecting information to support decision making aimed at analysing problem-solving systems and determining the time required by qualified labours for a given task and eliminating factors that make the job unsatisfactory.	Knowing the productivity of the labour to minimize the budget and time to obtain maximum results to receive good productivity values in the project.
Methods	Work sampling and historical experience.	Work sampling and NASA-TLX.	Work sampling method.	Work study method	Work sampling method.

Table 2.1 Previous Research Result (continued)

Aspect	Previous Research				
	Rizaldi (2021)	Nadhim et al. (2023)	Firda et al. (2023)	Wicaksono et al. (2023)	Walakutty et al. (2024)
Results	Work sampling obtained productivity results of 6,055 m²/day. From the historical experience method, the productivity value of the craftsman was 0,443 m³/hour/person and the labour 0,098 m³/hour/person. The method can be applied is the historical experience because this method is very practical where the work sampling method did not pass the data uniformity and adequacy test.	The magnitude of the physical workload carried out using the work sampling method on the production operator of the pump body production section is high at 74% approaching the maximum limit of 100%. From the results of NASA-TLX data processing, it is shown that the metal load factor that has a dominant influence is effort with a score of 2454.	The work sampling indicates that overall LUR of the bore pile construction project is 73,45% with high productivity 6,404 m²/hour/person. The highest labour productivity for all tasks occurred on Tuesday. The significance impact labour productivity at a 95% significance level include control and supervision, teamwork, and leadership.	The productivity value will be obtained based on the type of work, namely the marking of the plate is 563,25 kg/person/day and WF 886,47 kg/person/day. then for plate cutting: 891,85 kg/person/day and WF 259,53 kg/person/day. Finally, for the productivity value in assembly, it is 282,43 kg/person/day.	The result showed that the productivity for bricklaying work was 1.680 m²//hour/person, while for wall plastering work was 25,65 m²/hour/person. The LUR value for bricklaying work was 43,60% and for wall plastering work the LUR value was 36,20%.

Based on Table 2.1 until Table 2.3 above, this study is different from the previous study. The previous studies show clear points of difference in terms of context, methods, and measured outputs. Rizaldi (2021) focused on historical work sampling for craftsman productivity measured in m^2/day and $\text{m}^3/\text{hour}/\text{person}$, emphasizing practicality despite limitations in statistical adequacy. Nadhim et al. (2023) applied the NASA-TLX method to evaluate physical workload as a dominant factor. In contrast, Firda (2023) investigated the Labour Utilization Rate (LUR) within bore pile projects, highlighting daily fluctuations in productivity and the notable effects of supervision and teamwork. Similarly, Wicaksono et al. (2023) measured productivity by calculating task-specific outputs expressed in $\text{kg}/\text{person}/\text{day}$. Walakutty et al. (2024) focused on comparing productivity levels between bricklaying and plastering tasks, alongside determining their respective LUR figures.

Building on these varied approaches, the present research is positioned to contribute by combining work sampling methods with an examination of managerial and external factors that affect productivity within a particular construction setting. By exploring aspects that previous studies have only partially addressed such as site conditions and leadership influences this study seeks to offer a more holistic view of how different variables collectively shape construction productivity.

CHAPTER III THEORETICAL BASIS

3.1 Project Construction

Heizer et al. (2014) explain that a project can be defined as a series of tasks directed towards a main result. Similarly, Schwalbe (2014, as cited in Dimyati et al., 2014) states that a project is a temporary endeavour undertaken to create a unique product or service. In this context, construction refers to the activity of building a structure, and therefore, a construction project can be understood as an effort to complete a building within a specified time frame and with limited resources. A construction project is essentially an organized effort to achieve predetermined objectives within time and resource constraints.

To ensure successful completion, construction management plays a crucial role by planning, organizing, coordinating, and controlling every aspect of the project from initiation to completion. By applying systematic management techniques, construction management helps maintain a balance among cost, time, and quality while addressing potential risks and challenges. Through effective implementation, stakeholders can ensure that construction activities are carried out as planned, comply with technical specifications, and ultimately achieve the project's overall goals.

3.2 Construction Management

Construction management is how the resources involved in a construction project can be applied by the project manager appropriately (Ervianto, 2025). Construction management is discipline concerned with planning, coordinating, and overseeing construction projects from inception to completion. It involves a variety of tasks and responsibilities aimed at ensuring that construction projects are completed successfully, within budget, schedule, and established quality standards. Some key elements in construction management are:

1. Project planning is the initial stage where project planning is carried out, including determining the objectives, budget, and schedule of the project. It also involves analysing and identifying the resources required.
2. Cost management which includes managing the project budget, including planning, monitoring, and controlling expenditures to ensure the project remains within the established cost limits.
3. Time management is the key to managing the project schedule to ensure the project is completed on time is an important aspect of construction management. It includes time planning, monitoring the progress of the project, and adjusting if there are delays.
4. Resource management which involves managing the human resources, equipment, and materials required for the construction project. This includes recruiting labour, managing contractors, and ensuring adequate supplies of materials and equipment.
5. Risk management construction project often involves many risks, such as weather changes, soil problems, or changes in construction regulation. Risk management involves identifying, evaluating, and mitigating these risks.
6. Quality and supervision ensuring that construction work meets established quality standards is the responsibility of construction management. This involves constant supervision of the work and periodic inspections.
7. Communication and coordination construction managers must be effective in communicating with the project team, project owner, contractors, and other stakeholders. Good coordination is necessary to keep the project running smoothly.
8. Documentation construction management involves storing and managing project documents, including permits, contractor agreements, and supervision records.
9. Occupation health and safety ensuring that everyone involved in a construction project works in a safe environment is a top priority. This involves planning safety measures, training, and monitoring.

10. Post-construction maintenance construction management can also involve maintaining facilities after construction is complete, especially if the project involves buildings or infrastructure that must be maintained.

Construction management can be performed by the project owner, and independent construction manager, or a construction company. The goal is to achieve the project objectives efficiently, safely, and according to established specifications.

According to Teras et al. (2024), the function of construction managements to achieve the project's predetermined goals are:

- a. Planning

Planning can be defined as the formulation of a future vision and the activities that will be carried out to achieve the predetermined goals according to that project. Planning includes process plans, work methods, result measurement standards, costs, and activity schedule. The function of planning involves a decision-making process based on data, assumptions, information, and fact related to the activities to be undertaken.

- b. Organizing

Building a structure through various integrated components, so that the relationships between these parts are connected to the overall structure, is the meaning of organization. This phase is crucial because improper agreements and grouping of activities directly affect the project's direction.

- c. Actuating

Actuating is carried out by the contractor and project owner with the aim of achieving the expected results. Supervision functions to coordinate the implementation of activities as well as to distribute tasks, authority, and responsibilities. This aims to ensure that the right team is in the right position at the right time.

- d. Directing

This is the process of mobilizing available resource to function as a unified whole based on the established plan. This serves to realize a balance between

the duties, rights, and responsibilities of each organizational component as well as to create efficiency and synergistic cooperation.

e. Controlling

Controlling is an activity aimed at ensuring that the work is carried out according to the predetermined plan and follows the necessary stages. If there are activities that do not align with the plan or stages, corrective actions must be taken as needed.

Construction management serves as both the strategic and operational backbone of a project, ensuring that construction activities are executed efficiently, safely, and economically thereby directly enhancing overall productivity. The relationship between construction management and productivity is deeply intertwined; effective coordination of planning, resource allocation, cost control, and risk management fundamentally determine the efficiency, quality, and timeliness of project outcomes. This linkage is reinforced through comprehensive project planning that optimizes resources, time management that keeps schedules on track, and cost management that prevents waste while enabling investment in productivity enhancing measures. Effective resource management ensures the right personnel, materials, and equipment are deployed at the right time, while risk management minimizes potential disruptions. Quality control and supervision safeguard standards and reduce rework, and clear communication among stakeholders streamlines decision making and limits inefficiencies. Equally important, prioritizing occupational health and safety fosters a secure work environment, reducing accidents and downtime. Together, these principles form the operational foundation required to achieve and sustain of productivity in construction projects.

3.3 Productivity

The comparison between the totality of expenditure at a certain time and the totality of input during a period is the definition of productivity (Budiasih et al., 2023). In construction project contexts, productivity time refers to periods during which labour is actively engaged in performing assigned construction tasks that

directly contribute to project output. In contrast, non-productive time refers to periods during which labour is engaged in activities that do not directly contribute to construction output, such as waiting, idle time, unnecessary movement, or other work interruptions. Productivity is defined as the ability of a person, system, or company to produce quality results by utilizing resources effectively and efficiently. Productivity is the comparison between the output volume of a job to the amount of input from resources used to create welfare. Productivity can be formulated as:

$$P = \frac{\text{Output}}{\text{Input}}$$

Where:

P = Productivity

Output = Unit

Input = Time

Output is the expected result based on input management such as type, quantity, and time required. Output can be calculated through several units, namely:

1. Manpower through work hours.
2. Materials through volume units.
3. Machine through productivity machine work hours.
4. Money through currency units.
5. Method through work rules such as standard operating procedures (SOP).

Meanwhile, all resources used in processing something called input. Input is managed with a series of processes, methods, and effective and efficient ways of working by involving all parties to produce quality added value. Effectiveness, efficiency, and quality are elements found in productivity.

1. Effectiveness

Effectiveness is a comparison to measure the targets achieved. Effectiveness is obtained by comparing the evaluation of work output to input so that it can produce of effectiveness of a job. The greater percentage targets achieved, the higher of effectiveness.

2. Efficiency

Efficiency is the ability to use resources optimally to produce maximum output. The resources in question are time, energy, and cost. The fewer resources used, the more efficient a job is.

3. Quality

Quality is one of the elements of productivity that states how far the requirements, specifications, and expectations of an output are obtained. Therefore, input and output are important factors in achieving the quality.

Labour productivity in construction is influenced by appropriate skills, conducive work environments, fair compensation, and harmonious relationships. According to Kartika et al. (2020), labour activities are categorized into effective work, contributory work, and non- productivity activities, forming the basis for productivity assessment. Among various measurement techniques, methods such as time study, direct observation, productivity rate analysis, historical data review, surveys, and digital monitoring are commonly applied. However, this study adopts the work sampling method due to its efficiency, practicality, and ability to capture representative data in dynamic construction settings without disrupting workflow. Work sampling enables the calculation of the Labour Utilization Rate (LUR) by distinguishing productivity, contributory, and non- productivity time proportions. By integrating quantitative and qualitative approaches, labour productivity can be measured comprehensively, providing both numerical benchmarks and contextual insights. Ultimately, productivity data play a critical role in cost analysis, as higher productivity reduces unit prices and supports more competitive project implementation. Work sampling is one of method for measuring labour productivity in construction. It categorizes work into productivity, contributory, and non- productivity activities, providing valuable insights without disrupting workflow.

3.4 Work Sampling

Yuanto et al. (2018) mentioned that work sampling, also known as activity sampling, is a technique for measuring and analysing productivity by applying statistical principles, both for effective and ineffective activities. By taking random

samples (but must be able to represent the entire population) and then analysing them further. The random sample referred to here is that each individual or part of the population to be observed must have an equal chance of being taken as a sample, without any differences or emphasis on certain individuals, all elements are seen as having the same value. The biggest advantage of choosing this work sampling method over time study is the possibility of collecting data or studying many people at once in one study rather than using the time study method. In conducting research using work sampling, there are several methods that are usually applied or implemented for the data collection stage, with direct observation in the field, direct interviews with parties related to this research and by distributing written questionnaires to respondents who are considered qualified enough to provide accurate and accountable information. To analyse labour productivity effectively, various work sampling approaches can be applied. Each method offers a different level of detail and suitability depending on the research objectives and project conditions. Oglesby, Parker, and Howell (1989) stated the following are the main work sampling methods commonly used in construction study:

1. Field Rating

The simplest method, where random observations are made to record whether labour is working or idle, without further detail. It provides a rough estimate of labour status.

2. Five Minute Rating

Observations are conducted at short intervals (typically every minute over a five-minute period or longer). In each minute, the labour status is recorded as productivity or delayed. If more than 50% of the time in that minute is spent effectively, it is considered productivity. This method is useful for assessing the overall effectiveness of a crew on specific tasks.

3. Productivity Rating

This method classifies labour activities into two categories:

Effective work : Direct tasks contributing to the final output.

Essential contributory work : Indirect tasks that support completion, such as moving materials or checking drawings.

Work sampling methods provide different of accuracy and efficiency. Continuous observation offers detailed insights but requires significance time, while random or group sampling is more practical yet less precise. To achieve a balance between reliability and efficiency, this study applies the Five-Minute Rating method, which allows quick and meaningful evaluation of labour productivity without the need for prolonged observation.

3.5 The Five Minutes Rating

Oglesby, Parker, and Howell (1989, 112) assert that "work sampling provides an effective means of estimating productivity without continuous observation." the five-minute rating method is a quick and simple evaluation technique compared to field rating, yet effective for general work assessment. It is based on short-period observations to estimate crew effectiveness. However, it does not distinguish between delays that hinder progress and those that only increase costs, so results must be interpreted carefully. Observations are conducted discreetly, with individuals or subgroups monitored in short time blocks. The ratio of effective to total observed time is then calculated to determine overall labour effectiveness.

The steps involved in conducting observations using the work sampling method are outlined as follows:

1. Data Collect

The researcher determines the number of samples to be included in the study. For example, if a sample is recorded every 5 minutes, then within one hour, it is possible to obtain 96 observation samples in 1 day. Consequently, and 5 minutes for 1 sample, standard working 12 days, the total number of samples collected would $12 \text{ days} \times 96 \text{ samples} \times 5 \text{ labours} = 5.760 \text{ samples}$. Once the sample size has been established, the researcher observes the activities performed by the labour while executing their tasks. Each observed activity is then classified as either productivity or idle, using a structured observation from prepared.

2. Data Uniform Test

The data uniformity test is conducted to assess whether the collected observations are consistent and originate from a stable and controlled process. This test aims to determine whether the data fall within the established control limits, indicating that no significant variations or abnormal deviations occur during the observation period. If all data points within the upper and lower control limits, the data are considered uniform and suitable for further analysis. However, if certain observations fall outside the control limits, the data may be influenced by special causes of variation and should be reviewed or excluded to ensure analytical accuracy. At this stage, control limits are first established to determine the percentage of productivity on the day. The defined limits consist of the Upper Control Limit (UCL) and the Lower Control Limit (LCL), which are formulated as follows:

$$\begin{aligned}
 \sum p_i &= \text{Accumulation of Total Sampel in 12 days} \\
 k &= \text{Number of Observation Days} \\
 &= 12\text{days} \\
 n &= \text{Total Number of Observations} \\
 &= \frac{8 \text{ hours work time}}{5 \text{ minutes}} = 96 \text{ sample every labour} \\
 N &= 96 \text{ sample/day} \times 5 \text{ labour} \\
 &= 480 \text{ sample} \\
 \bar{n} &= \text{Average Number of Observations per Day} \\
 &= \frac{n}{k} = \frac{480}{12} = 40 \text{ sample} \\
 \bar{p} &= \text{Average Productivity} \\
 &= \frac{\sum p_i}{k} \\
 \text{UCL} &= \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{\bar{n}}} \\
 \text{LCL} &= \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{\bar{n}}}
 \end{aligned}$$

The control limits (LCL and UCL) are expressed in proportion since the analysis is based on the proportion of productive activities from total

observations. If a value of p falls outside the Upper Control Limit (UCL) or the Lower Control Limit (LCL), the corresponding observation for that day is considered invalid and must be discarded.

3. Data Sufficiency Test

The data sufficiency test is conducted to determine whether the number of observations collected is adequate to represent the actual working conditions with the desired of accuracy and confidence. This test ensures that the sample size is statistically sufficient to produce reliable and valid results. If the calculated required number of observations is less than or equal to the number of observations obtained, the data are considered sufficient. Conversely, if the required number exceeds the observed sample size, additional observations must be conducted to achieve statistical reliability.

$$\sum p_i = \text{Productivity average}$$

$$k = \text{Total day sampling}$$

$$N' = \text{Data Sufficiency}$$

$$= \frac{1600 (1 - \bar{p})}{\bar{p}}$$

4. Calculate Required Observation

Standard time refers to the reasonable amount of time required by an average qualified labour to complete a task under typical working conditions, representing the most productivity e or optimal performance observed at that time. Meanwhile, normal time is the duration needed by a labour to complete the task under standard conditions, reflecting average skill and effort. To determine the standard time, several calculations are required, including the following:

$$\text{Productivity} = \frac{\text{Total Unit Produced}}{\text{Total OH}}$$

Where:

- 1) Total Unit Produced is Volume of field work is based on the installed Joglo roof using pipe steel.
- 2) Total OH is Man in Day.

The calculation of labour productivity in this study is based on the results of work sampling observations conducted during the roof structure installation activities. Several parameters are used to determine the level of labour productivity, including the productivity percentage, total productive time, cycle time, and normal time. These parameters are calculated using the following formulas.

$$\text{a) Productive Percentage (PP)} = \frac{\text{Amount of productive Work}}{k} \times 100$$

$$\text{b) Total Productives in Minutes (TPM)} = PP \times k$$

$$\text{c) Cycle Time} = \frac{\text{TPM}}{\text{Total Unit Produce}}$$

$$\text{d) Normal Time} = \text{Cycle Time} \times \text{adjustment factor}$$

In analysing labour productivity for installation of Joglo style roofs using steel frames, this study employs the work sampling method as its primary observation technique. Work sampling is recognized in the construction industry for its ability to measure actual field performance objectively, while minimizing disruption to ongoing work activities. Adjustment factor and all formula can be derived from the values recorded by the labour during field observations in (Rizaldi, 2021). Subsequently calibrated using the factors provided in the Westinghouse evaluation table, as follows:

Skill			Effort		
+0.15	A1	Superskill	+0.13	A1	Excessive
+0.13	A2		+0.12	A2	
+0.11	B1	Excellent	+0.10	B1	Excellent
+0.08	B2		+0.08	B2	
+0.06	C1	Good	+0.05	C1	Good
+0.03	C2		+0.02	C2	
0.00	D	Average	0.00	D	Average
-0.05	E1	Fair	-0.04	E1	Fair
-0.10	E2		-0.08	E2	
-0.16	F1	Poor	-0.12	F1	Poor
-0.22	F2		-0.17	F2	
Conditions			Consistency		
+0.06	A	Ideal	+0.04	A	Perfect
+0.04	B	Excellent	+0.03	B	Excellent
+0.02	C	Good	+0.01	C	Good
0.00	D	Average	0.00	D	Average
-0.03	E	Fair	-0.02	E	Fair
-0.07	F	Poor	-0.04	F	Poor

Figure 3. 1 Performance Rating Table (Westinghouse)

(Source: Salvendy, 2001)

a. Skill

Skill is defined as the labours ability to follow established procedures accurately. The levels of skill can be classified as follows:

- 1) Super Skill, labour naturally suited to the task, performing seamlessly and swiftly so that movements appear automatic, almost machine like, with fluid transitions between work elements and recognized as the best among their peers.
- 2) Excellent Skill, confident and well trained, demonstrating precision, working quickly without compromising quality, maintaining consistent and coordinated movements, and fully suited to the job.
- 3) Good Skill, produce high quality work, performs better than the average labour, can guide colleagues with lower skills, requires minimal supervision, maintains stability, and shows well-coordinated and fast movements.
- 4) Average Skill, displays adequate confidence, performs at a moderate but steady pace, engages in planning, shows sufficient knowledge of the task, and generally delivers satisfactory results.

- 5) Fair Skill, has some training but lacks confidence, sometimes appears hesitant or not fully suited to the role, occasionally wastes time due to errors, and output may drop without sustained effort.
- 6) Low Skill, lacks coordination, movements are stiff and hesitant, appears untrained or unfit for the task, makes frequent mistakes, and shows little initiative.

b. Effort

Effort reflects the level of commitment and energy the labour dedicates to the task, categorized as follows:

- 1) Excessive Effort works at an unsustainably high speed that could risk health and cannot be maintained throughout the workday.
- 2) Excellent Effort, demonstrates high speed and efficiency, pays close attention to the task, rarely makes mistakes, is receptive to suggestions, and actively contributes ideas for improvement.
- 3) Good Effort, maintains a steady rhythm, minimizes idle time, enjoys the work, keeps the workplace organized, accepts feedback positively, and consistently performs well throughout the day.
- 4) Average Effort, performs steadily through less effectively than higher levels, accepts suggestions but rarely applies them, and still engages in planning activities.
- 5) Fair Effort shows less commitment, occasionally distracted, overly cautious, sometimes uses suboptimal tools, and does not consistently pay attention to work quality.
- 6) Low Effort, frequently wastes time, lacks interest, resists suggestions, works slowly, and keeps a disorganized workspace.

c. Conditions

This refers to the physical environment where the task is performed, such as lighting, temperature, and noise, which can influence performance. Conditions

are categorized as ideal, excellent, good, average, fair, and poor. Poor conditions may hinder task completion.

d. Consistency

The consistency factor measures how steady and uniform an operator performs a task over time.

- 1) Perfect, consistent and uniform performance.
- 2) Excellent, very consistent with only minor variations.
- 3) Good, generally consistent, but occasional slight variation.
- 4) Average, acceptable with moderate variations in rhythm.
- 5) Fair, noticeable inconsistencies, affecting performance.
- 6) Poor, highly inconsistent, erratic work pattern.

3.6 Standard and Implementation Guidelines

In the implementation of the *Joglo* steel roof structure construction, this study refers to the Circular Letter of the Directorate General of Construction Development Number 182/SE/DK/2025 (SE DJB No. 182/SE/DK/2025) as the primary reference for labour productivity standards. This regulation provides standardized labour productivity coefficients expressed in man-hours per unit of work, which are commonly used as benchmarks in construction planning, cost estimation, and project scheduling. These standardized coefficients serve as reference values for evaluating labour performance during construction activities. By comparing field productivity with the national standards stated in SE DJB No. 182/SE/DK/2025, it is possible to assess whether the observed productivity levels meet, exceed, or fall below the expected performance benchmarks. Such comparisons provide an objective basis for identifying potential inefficiencies in labour utilization during project implementation.

In this research, labour productivity data are obtained using the work sampling method with the Five Minutes Rate technique. This method allows the classification of labour activities into productive and non-productive time through periodic observations conducted at fixed time intervals. The collected data are then used to

calculate the productivity percentage, cycle time, normal time, and standard time, which form the basis for determining labour productivity. Furthermore, the calculated productivity values are compared with the standards specified in SE DJB No. 182/SE/DK/2025 to evaluate the efficiency of labour performance in the steel roof structure installation process. This comparison provides a systematic framework for analysing productivity gaps between field conditions and established national benchmarks. The results of this analysis are expected to contribute to improving labour planning, productivity evaluation, and workforce management in similar construction projects. Presents the standard labour output for each work item based on the reference standards used as benchmarks in this study, as shown below :

Table 3. 1 Standard Labour Output and References Work Item

2.3.1.2 1 kg Pabrikasi dan Ereksi Baja Profil

No	Uraian	Kode	Satuan	Koefisien	Harga Satuan (Rp)	Jumlah Harga (Rp)
A	Tenaga Kerja					
	Pekerja	L.01	OH	0,0375		
	Tukang besi/besi beton	L.02	OH	0,0125		
	Kepala Tukang	L.03	OH	0,0025		
	Mandor	L.04	OH	0,0008		
	Jumlah Harga Tenaga Kerja					
B	Bahan					
	Baja Profil		kg	1,15		
	Kawat las		kg	0,053		
	Jumlah Harga Bahan					
C	Peralatan					
	Alat las Listrik		jam	0,033		
	Crane Mobile 7 ton		jam	0,0013		
	Jumlah Harga Alat					
D	Jumlah Harga Tenaga Kerja, Bahan dan Peralatan (A+B+C)					
E	Biaya Umum dan Keuntungan (10% - 15%) x D					% x D
F	Harga Satuan Pekerjaan (D+E)					

Catatan: HSD alat sudah termasuk operator alatnya (tanpa pembantu operator)

(Source: SE DJB No 182/SE/Dk/2025)

Based on Table 3.1 The labour productivity shown in the table represents the amount of working time required to produce 1 kg of steel profile fabrication and erection work. The relatively small labour coefficient values indicate that the work is quite efficient and does not require excessive time per unit of output. General labours have a coefficient of 0,0375 OH, steel labours 0,0125 OH, foremen 0,0025 OH, and supervisors 0,0008 OH. This indicates that the largest contribution in the work process comes from the skilled labours, while supervisory roles such as foremen and supervisors have smaller contributions but remain essential for

maintaining quality and coordination. Overall, this composition reflects a balanced distribution between operational and supervisory labour, enabling optimal productivity through efficient use of the workforce.

3.7 Roof Truss

Roof truss construction is a form of construction that has the function of supporting the roof construction located on the truss. More specifically, the function of the roof truss is to receive the load of the truss and the coating material in the vertical direction then distributed to the column and foundation and withstand the wind pressure of the load in the horizontal direction on the gavel (Oktarina, 2015).

Roof truss construction is generally made of wood with roof coverings made of tiles, zinc, asbestos, or metal sheets. However, wood has weaknesses such as uneven quality, weathering by termites, expanding or shrinking due to weather, and flammability. Therefore, roof truss with steel structure are an option as a substitute that currently wood materials are difficult to obtain so that the price is relatively more expensive.

In the construction of the roof truss, there are several requirements that must be obtained, including:

1. The roof construction must be strong enough to support its own weight and withstand pressure and wind.
2. The selection of the shape of the roof to be used must be appropriate to add the aesthetics and comfort of the building.
3. The slope or angle of the roof slope must be adjusted to the type of material used.

3.8 Steel Structure

The steel structure is using ASTM A500 Grade B steel is known for its minimum tensile strength of 290 MPa, offering stable mechanical properties and good weldability, making it highly suitable for structural load-bearing applications. These pipes fall under the Circular Hollow Section (CHS) category and are equivalent to international standards such as BS EN 10210-1, which govern high-performance, deformation-resistant structural hollow sections with circular, square,

or rectangular profiles. In Indonesia, these standards have been formally adopted under SNI 7391:2008 titled “*Steel Pipes for Structures*”, along with other SNI standards that regulate the use of structural steel in construction. The pipes are galvanized for corrosion resistance and further protected with epoxy coating and anti corrosive finishing, making them particularly well suited for long term use in humid or open tropical environments.

Table 4 — Test units

Type of hollow section		Test unit
Circular	Square, rectangular or elliptical	
Outside diameter <i>D</i> mm	External perimeter mm	Mass maximum t
≤ 114,3	≤ 400	40
> 114,3 ≤ 323,9	> 400 ≤ 800	50
> 323,9	> 800	75

Figure 3. 2 Steel Structure

(Source : EN 10210-1: EUROPEAN STANDARD)

The Figure 3.3 steel pipes conforming to ASTM A500 Grade B, with an outer diameter of 114 mm (4 inches) the wall thickness is 3.2 mm and the weight is 8,7 kg/m, are widely utilized as structural materials in building construction. Their applications range from traditional roof structures such as the *Joglo* to various forms of modern architecture.

CHAPTER IV METHODOLOGY

4.1 Research Method

The research methodology in this final project is quantitative method. The research will investigate specific conditions by quantitative data collection and analysis using scientific approaches. The method is work sampling resulting in productivity analysis. The method involves work duration, technical, and productivity data of the labours, as well as refining the obtained data, to then be analysed using applications such as Microsoft Excel and Microsoft Word.

4.2 Research Location

Research location is in Gadjah Mada University, Sleman, Special Region of Yogyakarta, as shown in Figure 4.1 and Figure 4.2 below.

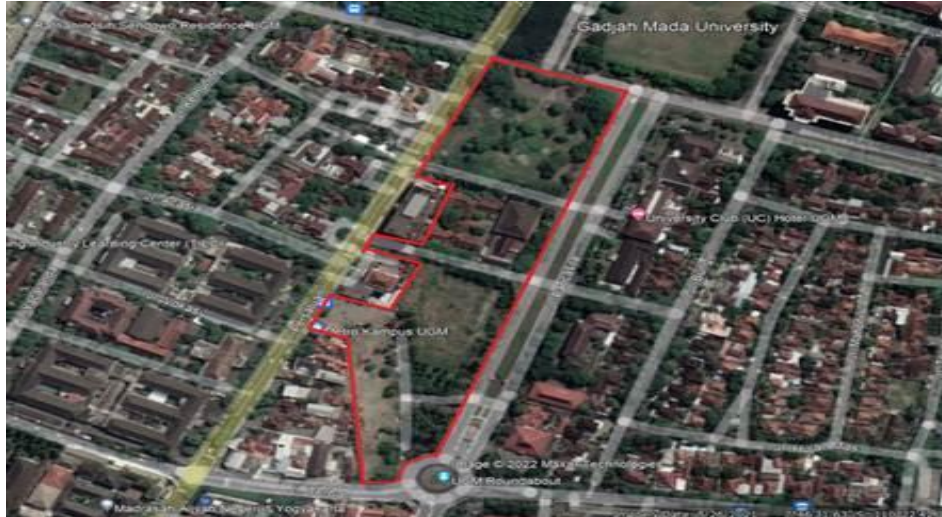


Figure 4. 1 Project Location of Gelanggang Inovasi Kreativitas Building

(Source: Project Document Waskita – Amarta, KSO)



Figure 4. 2 Project Map of Gelanggang Inovasi Kreativitas Building

(Source: Project Document Waskita – Amarta, KSO)

4.3 Research Object and Subject

The object of this study is to examine the productivity of construction labours in specifically those involve in the Joglo roof steel structure installation at the Gelanggang Inovasi Kreativitas Gadjah Mada University project specific at zona G, which is analysed through direct field observations using the work sampling method ad compared against the standards of the Regulation of the Minister of Public Works and Public Housing.

4.4 Joglo Roof Structure

The types of roofs include gable roofs and hip or *Tajug* roofs. A gable roof consists of two sloping roof planes with the upper edges connecting in a straight line called the ridge. The gable roof shape is usually used for simple houses. While the hip or *Tajug* roof is shaped like a pyramid. This roof has better protection from sun and rain. Although it looks magnificent, this type of roof has the disadvantage of complicated and expensive construction because it uses many trusses. The hip or *Tajug* roof can be found in Joglo building. In this study, the technical drawing (construction drawing) of the roof is used as the main reference for structural analysis and work calculation. The drawing serves as the basis for determining dimensions is 1.800 m², roof frame details, and volume 50839,38 kg, ensuring that

the analysis is conducted systematically and accurately, as shown in Figure 4.3 – figure 4.5. The technical drawing figure will be attached in Appendix 14 – 16.

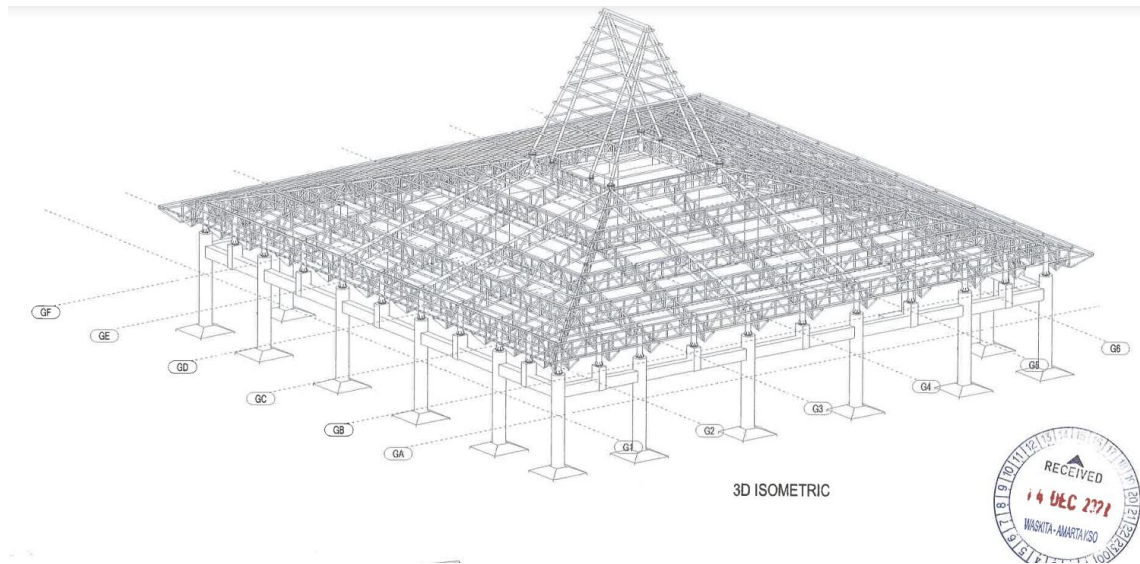


Figure 4. 3 3D Isometric Steel Roof

(Source: Project Document Waskita – Amarta, KSO)

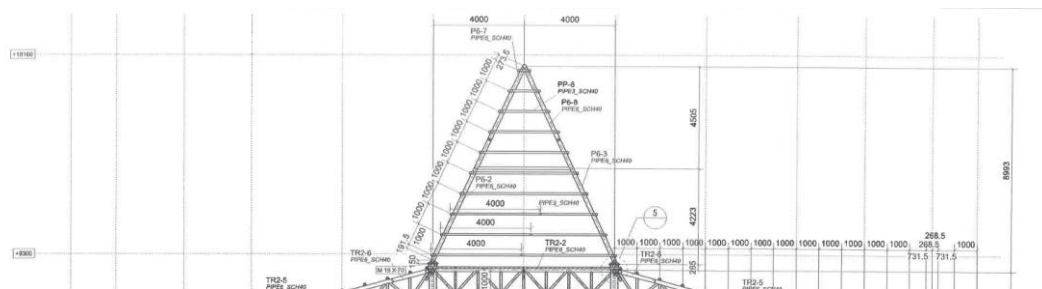


Figure 4. 4 Framing Axis Line Limasan

(Source: Project Document Waskita – Amarta, KSO)

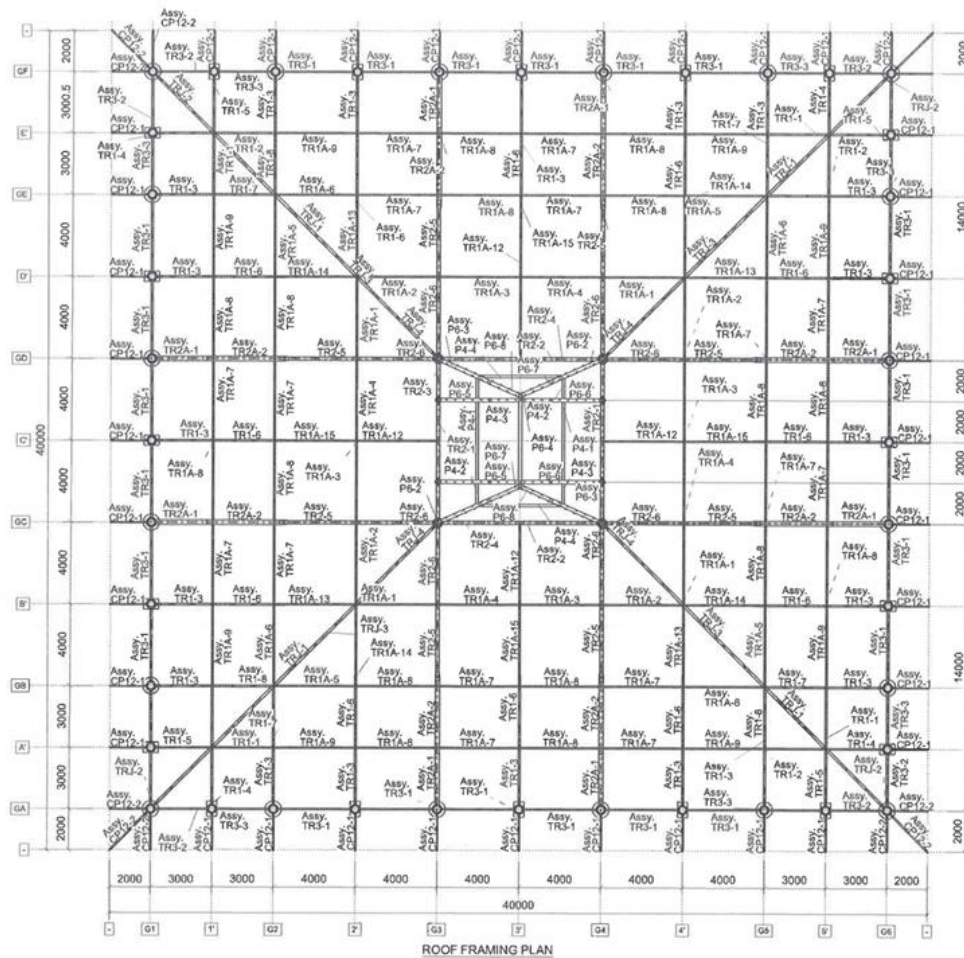


Figure 4.5 Roof Framing Plan

(Source: Project Document Waskita – Amarta, KSO)

4.5 Types of Data

The productivity study employed work sampling to collect primary categorical data related to labours activities (productivity) at fixed intervals. This data was supplemented with secondary quantitative data, including work volume and standard coefficients, to calculate actual productivity rates. The resulting dataset thus consists of a combination of categorical data (activity type) and numerical data (frequency counts, man-hours, productivity rates), which together provide a comprehensive basis for productivity analysis. The data is classified as follows:

1. Primary Data

Primary data comprise information acquired directly from the field. This data collection is conducted through systematic on-site observations to obtain accurate and current information relevant to the project.

2. Secondary Data

Secondary data refer to information gathered indirectly, typically through intermediaries. In this study, secondary data include information obtained by conducting standard productivity coefficients or norms from the SE DJB No 182/SE/Dk/2025.

4.6 Data Collection

In this research, the data is obtained from Gelanggang Inovasi Kreativitas Gadjah Mada University Project. The data collection is done in the following steps:

1. Secondary Data

Secondary data includes technical data of Gelanggang Inovasi Kreativitas Gadjah Mada University Project as well as scheduling and other supporting documents of the Project.

2. Observation

Observation is done on the field, as an important part of research. This method is done to collect legitimate data from the research object.

In this study, total of 96 samples was collected from each labour in day, with observations taken at 5-minute intervals throughout an 8 hour work shift. Consequently, the overall number of samples obtained during the 12 days on Monday, 13 March 2023 until Saturday, 25 March 2023 observation period amounted to 5.760 (12 day $\times$ 96 sample $\times$ 5 labour) observation units. The data collection process was conducted with the assistance of one colleague, involving a workforce consisting of two welders and three helpers. For the field observation data collection, a standardized template form was utilized to facilitate and streamline the recording process.

The following is the observation data collection form used in this study:

Tabel 4. 1 Form Observation Data of Labour Productivity in the Field

[illegible]

Continue Table 4.1 Form Observation Data of Labour Productivity in the Field

[illegible]

Continue Table 4.1 Form Observation Data of Labour Productivity in the Field

Monday, 13 March 2023												
No	Time	Labours										Notes
		Welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
69	13:40											
70	13:45											
71	13:50											
72	13:55											
73	14:00											
74	14:05											
75	14:10											
76	14:15											
77	14:20											
78	14:25											
79	14:30											
80	14:35											
81	14:40											
82	14:45											
83	14:50											
84	14:55											
85	15:00											
86	15:05											
87	15:10											
88	15:15											
89	15:20											
90	15:25											
91	15:30											
92	15:35											
93	15:40											
94	15:45											
95	15:50											
96	15:55											
Total												
Total Time Productives												
Total Time Idle												
Volume Produced (kg)												

Where:

P = Productive

I = Non – Productive (Idle)

The use of a structured observation form not only facilitated consistency and accuracy in field data collection but also provided a systematic foundation upon which the subsequent research stages were carefully designed and implemented.

4.7 Research Stages

The implementation of this research consists of the following stages:

1. Problem formulation, which includes defining the research topic, formulating the research questions, and describing the significance and objectives of the study.
2. Literature review, conducted to gather and examine relevant information from various sources such as academic books, scientific literature, reports, and other references related to the research topic.
3. Data collect, involves gathering the necessary data to support the research analysis. The collected data includes the number of labours, project duration, project planning documents, working drawings, work volume, and productivity data of the labours, specifically for steel structure installation tasks.
4. Data analysis, in which the collected data are processed and evaluated. This analysis is carried out by calculating the actual productivity of the labours on site based on the predetermined method and comparing it with the SE DJB No 182/SE/Dk/2025

Conclusions on the final stage where the analysed data are summarized into conclusions that align with the initial research objectives.

4.8 Flowchart

A research flowchart is a visual depiction of a process, system, or algorithm. Standardized symbols are used to illustrate the stages of the process and the choices that need to be made at each stage. Flowcharts can be used to manage, create,

document, or analyse a process or system. They can also be used to explain it to others. They make a process easier to understand and follow by providing a concise and unambiguous description of its steps.

The flowchart of this research is shown below:

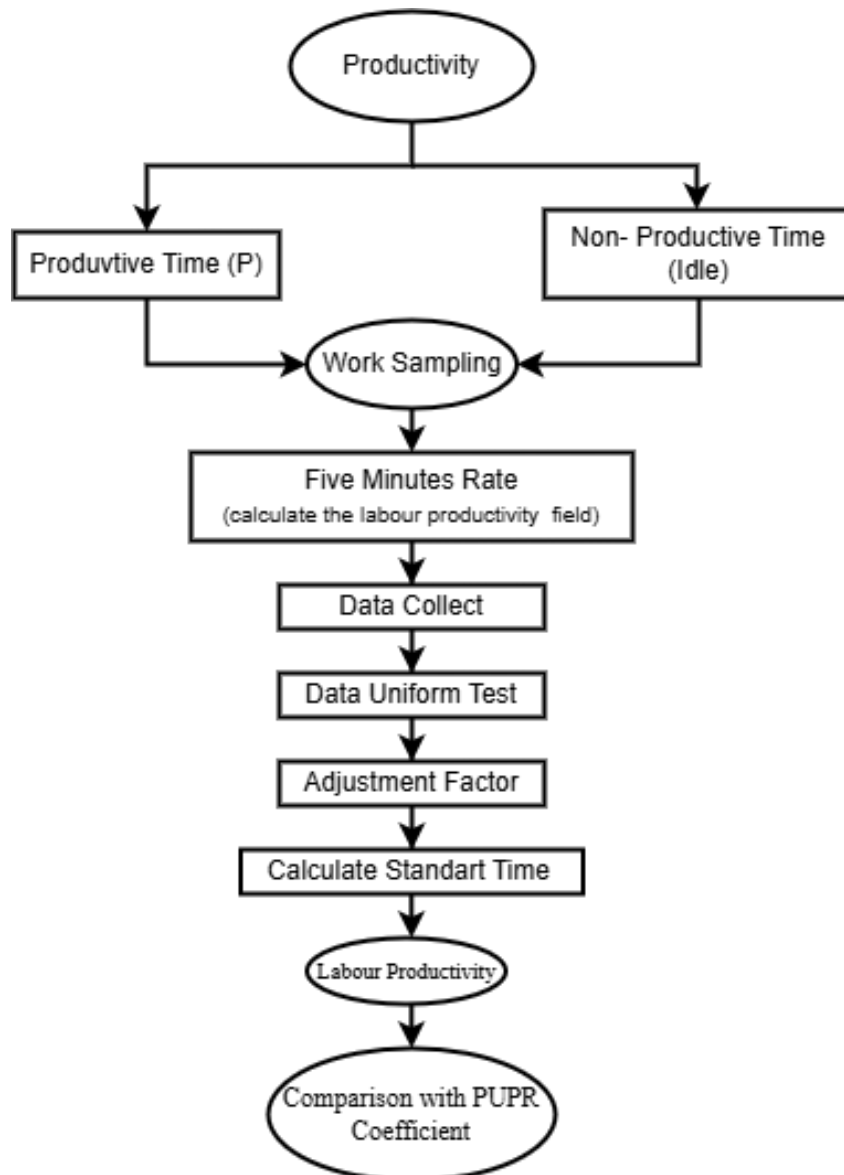


Figure 4. 6 Flowchart of Research

CHAPTER V

ANALYSIS DISCUSSION

5.1 Observation Object Analysis

In this research, data was collected through direct observation of labour in the field, specifically those involved in the *joglo* roof steel structure installation at the Gelanggang Inovasi Kreativitas (GIK) UGM project. Observations were recorded involving 5 labours with various job roles such as welder, helper.

Through this observation and recording process, the division between productive time and idle time of the labour force can be identified. Productive time, in contrast, non-productive time encompasses activities that are not directly associated with the preparation such as eating, drinking, smoking, socializing, daydreaming, leaving the work area, or sitting idly without engaging in any work-related tasks. Once the observational data is collected, the next stage involves conducting an analysis and discussion using the Work Sampling Method. The labour productivity results obtained will then be compared to the SE DJB No 182/SE/Dk/2025, to assess the efficiency and effectiveness of the labour on site.

5.2 Data Analysis

Before conducting the observations, it is necessary to first determine the required sample size for each labours. In this study, the number of samples taken for each labours was 96 samples/day, with each sample lasting 5 minutes. Therefore, the total number of samples collected during the 12 day observation period was $(12 \text{ days} \times 96 \text{ sample} \times 5 \text{ labour}) = 5.760$ observation samples. During the observations, the researcher was assisted by one colleague, allowing five labours to be observed simultaneously in one day.

5.2.1 Data Labour Observation

This section presents the results of the labour observation conducted during the field study. The observation was carried out systematically using a standardized template form to ensure of the data collected. The data focus on recording the

activities and productivity of labours at specified intervals, thereby providing a comprehensive overview of labour performance within the project. The findings obtained from this observation serve as the primary basis for analysing productivity.

The sample observed on the first day is presented in Table 5.1, Labour Productivity Installation of the Steel Structure for *Joglo* Roof on day one observation, as follows:

Table 5 . 1 Observation Data of Labour Productivity in the Field Day 1

Monday, 13 March 2023												
No	Time	Labours										Notes
		Welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
1	08:00		v		v	v		v		v		
2	08:05		v		v	v		v		v		
3	08:10		v		v	v		v		v		
4	08:15		v	v		v		v		v		
5	08:20		v	v		v		v		v		
6	08:25	v		v		v		v		v		
7	08:30	v		v		v		v		v		
8	08:35	v		v		v		v		v		Work Time
9	08:40	v		v			v		v		v	
10	08:45	v		v		v		v		v		
11	08:50	v		v		v		v		v		
12	08:55	v		v		v		v		v		
13	09:00	v		v		v		v		v		
14	09:05	v		v		v		v		v		
15	09:10	v		v		v		v		v		
16	09:15	v		v		v		v		v		
17	09:20	v		v		v		v		v		
18	09:25	v		v		v		v		v		
19	09:30	v		v		v		v		v		
20	09:35	v		v		v		v		v		
21	09:40	v		v		v		v		v		
22	09:45	v		v		v		v		v		
23	09:50	v		v		v		v		v		
24	09:55	v		v		v		v		v		

Continue Table 5.1 Observation Data of Labour Productivity in the Field

Monday, 13 March 2023												
No	Time	Labours										Notes
		Welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
25	10:00		v	v		v		v		v		Work Time
26	10:05	v		v		v		v		v		
27	10:10	v		v		v		v		v		
28	10:15	v			v	v		v		v		
29	10:20	v		v		v		v		v		
30	10:25	v			v	v		v		v		
31	10:30	v		v		v		v		v		
32	10:35	v		v			v		v		v	
33	10:40	v		v			v		v		v	
34	10:45	v		v		v		v		v		
35	10:50	v		v		v		v		v		
36	10:55	v		v		v		v		v		
37	11:00	v		v		v		v		v		
38	11:05	v		v		v		v		v		
39	11:10		v	v		v		v		v		
40	11:15	v		v		v		v		v		
41	11:20	v		v		v		v		v		
42	11:25	v		v		v		v		v		
43	11:30	v		v		v		v		v		
44	11:35	v		v		v		v		v		
45	11:40	v		v		v		v		v		
46	11:45	v		v			v		v		v	
47	11:50	v		v			v		v		v	
48	11:55		v		v		v		v		v	
49	12:00		v		v		v		v		v	
50	12:05		v		v		v		v		v	
51	12:10		v		v		v		v		v	
52	12:15		v		v		v		v		v	
53	12:20		v		v		v		v		v	
54	12:25		v		v		v		v		v	
55	12:30		v		v		v		v		v	
56	12:35		v		v		v		v		v	
57	12:40		v		v		v		v		v	
58	12:45		v		v		v		v		v	
59	12:50		v		v		v		v		v	
60	12:55		v		v		v		v		v	
Break Time												

Continue Table 5.1 Observation Data of Labour Productivity in the Field

Monday, 13 March 2023												
No	Time	Labours										Notes
		Welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
61	13:00		v		v		v		v		v	Work Time
62	13:05		v		v		v		v		v	
63	13:10	v		v			v		v		v	
64	13:15	v		v			v		v		v	
65	13:20	v		v			v		v		v	
66	13:25	v		v			v		v		v	
67	13:30	v		v			v		v		v	
68	13:35	v		v		v		v		v		
69	13:40	v		v		v		v		v		
70	13:45	v		v		v		v		v		
71	13:50	v		v		v		v		v		
72	13:55	v		v		v		v		v		
73	14:00	v		v		v		v		v		
74	14:05	v		v		v		v		v		
75	14:10	v		v		v		v		v		
76	14:15	v		v		v		v		v		
77	14:20	v		v		v		v		v		
78	14:25		v		v	v		v		v		
79	14:30	v		v		v		v		v		
80	14:35	v		v		v		v		v		
81	14:40	v		v		v		v		v		
82	14:45	v		v		v		v		v		
83	14:50	v		v		v		v		v		
84	14:55	v		v		v		v		v		
85	15:00	v		v		v		v		v		
86	15:05	v		v		v		v		v		
87	15:10	v		v		v		v		v		
88	15:15	v		v		v		v		v		
89	15:20	v		v		v		v		v		
90	15:25	v		v		v		v		v		
91	15:30	v		v		v		v		v		
92	15:35	v		v		v		v		v		
93	15:40	v		v		v		v		v		
94	15:45	v		v		v		v		v		
95	15:50	v		v		v		v		v		

Continue Table 5.1 Observation Data of Labour Productivity in the Field

Monday, 13 March 2023												
No	Time	Labours										Notes
		Welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
96	15:55	v		v		v		v		v		
Total		73	23	75	21	71	25	71	25	71	25	
Total Time Productives		361										
Total Time Idle		119										
Volume Produced (kg)		84,56										

Where :

P = Productive

I = Non – Productive (Idle)

The table presenting the frequency of labour observations day 1 and over the 12 days observation period is shown in Appendix 1- 13.

Table 5 . 2 Total Observation Frequency

Analysis	Labour	Observation Days												$\sum p_i$ (Total Sample)
		1	2	3	4	5	6	7	8	9	10	11	12	
Productives	Welder 1	73	76	77	74	67	73	74	75	75	76	78	82	900
	Welder 2	75	74	74	69	71	75	73	76	74	73	78	80	892
	Helper 1	71	76	78	71	79	73	77	67	75	83	82	77	909
	Helper 2	71	76	78	71	79	73	71	67	71	83	82	77	899
	Helper 3	71	76	78	71	71	73	73	67	71	83	82	77	893
Non – productives (idle)	Welder 1	23	20	19	22	29	23	22	21	21	20	18	14	252
	Welder 2	21	22	22	27	25	21	23	20	22	23	18	16	260
	Helper 1	25	20	18	25	17	23	19	29	21	13	14	19	243
	Helper 2	25	20	18	25	17	23	25	29	25	13	14	19	253
	Helper 3	25	20	18	25	25	23	23	29	25	13	14	19	259
$\bar{\rho}$ Average Productives	Welder 1	0,76	0,79	0,80	0,77	0,70	0,76	0,77	0,78	0,78	0,79	0,81	0,85	9,38
	Welder 2	0,78	0,77	0,77	0,72	0,74	0,78	0,76	0,79	0,77	0,76	0,81	0,83	9,29
	Helper 1	0,74	0,79	0,81	0,74	0,82	0,76	0,80	0,70	0,78	0,86	0,85	0,80	9,47
	Helper 2	0,74	0,79	0,81	0,74	0,82	0,76	0,74	0,70	0,74	0,86	0,85	0,80	9,36
	Helper 3	0,74	0,79	0,81	0,74	0,74	0,76	0,76	0,70	0,74	0,86	0,85	0,80	9,30
Volume Produced (kg)		84,56	87,95	91,83	93,23	88,49	95,50	83,28	88,51	91,28	80,93	86,10	75,57	1047,23

5.2.2 Data Uniformity Test

Conducting detailed productivity calculations, it is essential to assess the uniformity of the observed data. This step ensures that the data collected during the observation period is sufficiently consistent and representative of actual field conditions. Providing a sound basis for interpreting labour productivity on the steel structure installation for the *Joglo* roof project.

a. Welder 1

$$\begin{aligned}
 \sum_{k} p_i &= 9,38 \text{ (average total productives welder 1)} \\
 k &= 12 \text{ days} \\
 \sum n &= 480 \text{ sample} \\
 \bar{n} &= \frac{\sum n}{k} = \frac{480}{12} = 40 \text{ sample} \\
 \bar{p} &= \frac{\sum p_i}{k} = \frac{9,38}{12} = 0,78 \\
 UCL &= \bar{p} + \frac{3\sqrt{\bar{p}(1-\bar{p})}}{\bar{n}} \\
 &= 0,78 + \frac{3\sqrt{0,78(1-0,78)}}{40} = 0,97 \\
 LCL &= \bar{p} - \frac{3\sqrt{\bar{p}(1-\bar{p})}}{\bar{n}} \\
 &= 0,78 - \frac{3\sqrt{0,78(1-0,78)}}{40} = 0,58
 \end{aligned}$$

b. Welder 2

$$\begin{aligned}
 \sum_{k} p_i &= 9,29 \text{ (average total productives welder 2)} \\
 k &= 12 \text{ days} \\
 \sum n &= 480 \text{ sample} \\
 \bar{n} &= \frac{\sum n}{k} = \frac{480}{12} = 40 \text{ sample} \\
 \bar{p} &= \frac{\sum p_i}{k} = \frac{9,29}{12} = 0,77 \\
 UCL &= \bar{p} + \frac{3\sqrt{\bar{p}(1-\bar{p})}}{\bar{n}} \\
 &= 0,77 + \frac{3\sqrt{0,77(1-0,77)}}{40} = 0,97 \\
 LCL &= \bar{p} - \frac{3\sqrt{\bar{p}(1-\bar{p})}}{\bar{n}} \\
 &= 0,77 - \frac{3\sqrt{0,77(1-0,77)}}{40} = 0,57
 \end{aligned}$$

c. Helper 1

$$\begin{aligned}
 \sum_k p_i &= 9,47 \text{ (average total productives Helper 1)} \\
 k &= 12 \text{ days} \\
 \sum n &= 480 \text{ sample} \\
 \bar{n} &= \frac{\sum n}{k} = \frac{480}{12} = 40 \text{ sample} \\
 \bar{p} &= \frac{\sum p_i}{k} = \frac{9,47}{12} = 0,79 \\
 UCL &= \bar{p} + \frac{3\sqrt{\bar{p}(1-\bar{P})}}{\bar{n}} \\
 &= 0,79 + \frac{3\sqrt{0,79(1-0,79)}}{40} = 0,98 \\
 LCL &= \bar{p} - \frac{3\sqrt{\bar{p}(1+\bar{P})}}{\bar{n}} \\
 &= 0,79 - \frac{3\sqrt{0,79(1+0,79)}}{40} = 0,59
 \end{aligned}$$

d. Helper 2

$$\begin{aligned}
 \sum_k p_i &= 9,36 \text{ (average total sample helper 2)} \\
 k &= 12 \text{ days} \\
 \sum n &= 480 \text{ sample} \\
 \bar{n} &= \frac{\sum n}{k} = \frac{480}{12} = 40 \text{ sample} \\
 \bar{p} &= \frac{\sum p_i}{k} = \frac{9,36}{12} = 0,78 \\
 UCL &= \bar{p} + \frac{3\sqrt{\bar{p}(1-\bar{P})}}{\bar{n}} \\
 &= 0,78 + \frac{3\sqrt{0,78(1-0,78)}}{40} = 0,98 \\
 LCL &= \bar{p} - \frac{3\sqrt{\bar{p}(1+\bar{P})}}{\bar{n}} \\
 &= 0,78 - \frac{3\sqrt{0,78(1+0,78)}}{40} = 0,58
 \end{aligned}$$

e. Helper 3

$$\begin{aligned}
 \sum_k p_i &= 9,30 \text{ (average total sample helper 3)} \\
 k &= 12 \text{ days} \\
 \sum n &= 480 \text{ sample} \\
 \bar{n} &= \frac{\sum n}{k} = \frac{480}{12} = 40 \text{ sample} \\
 \bar{p} &= \frac{\sum p_i}{k} = \frac{9,39}{12} = 0,77
 \end{aligned}$$

$$\begin{aligned}
 \text{UCL} &= \bar{p} + \frac{3\sqrt{\bar{p}(1-\bar{P})}}{\bar{n}} \\
 &= 0,78 + \frac{3\sqrt{0,78(1-0,78)}}{40} = 0,97 \\
 \text{LCL} &= \bar{p} - \frac{3\sqrt{\bar{p}(1+\bar{P})}}{\bar{n}} \\
 &= 0,78 - \frac{3\sqrt{0,78(1+0,78)}}{40} = 0,57
 \end{aligned}$$

The recapitulation of the uniformity calculation results is presented in the following table.

Table 5 . 3 Recapitulation of The Uniformity Calculation

Labours	$\bar{p} = \frac{\sum p_i}{k}$	$\bar{n} = \frac{\sum n}{k}$	$\text{UCL} = \bar{p} + \frac{3\sqrt{\bar{p}(1-\bar{P})}}{N}$	$\text{LCL} = \bar{p} - \frac{3\sqrt{\bar{p}(1-\bar{P})}}{N}$
Welder 1	0,78	40	0,98	0,59
Welder 2	0,77	40	0,97	0,58
Helper 1	0,79	40	0,98	0,59
Helper 2	0,78	40	0,98	0,58
Helper 3	0,77	40	0,97	0,57
Average			0,97	0,58

Based on the results of the UCL and LCL calculations and the control charts for each labour the average Upper Control Limit (UCL) is 0,97 and the average Lower Control Limit (LCL) is 0,58. All observed proportions fall within the control limits, indicating that the labour performance is statistically under control. No significant variation beyond the three-sigma control limits was detected, suggesting process stability across welders and helpers.

5.2.3 Data Sufficiency Test

This test aims to determine whether the collected sample data are adequate to represent actual field conditions. By ensuring sufficient data, the analysis results become more reliable and accurately reflect labours productive.

a. Welder 1

$$\begin{aligned}
 \sum n &= 480 \text{ sample} \\
 \bar{p} &= 0,78
 \end{aligned}$$

$$\begin{aligned}
 N' &= \frac{1600(1-\bar{p})}{\bar{p}} \\
 &= \frac{1600(1-0,78)}{0,78} \\
 &= 448,00
 \end{aligned}$$

The results of the data sufficiency test for Welder 1 show that $N' < N$, indicating that the collected data are adequate and sufficient for further analysis.

b. Welder 2

$$\begin{aligned}
 \sum n &= 480 \text{ sample} \\
 \bar{p} &= 0,77 \\
 N' &= \frac{1600(1-\bar{p})}{\bar{p}} \\
 &= \frac{1600(1-0,77)}{0,77} \\
 &= 466,36
 \end{aligned}$$

The results of the data sufficiency test for Welder 2 show that $N' < N$, indicating that the collected data are adequate and sufficient for further analysis.

c. Helper 1

$$\begin{aligned}
 \sum n &= 480 \text{ sample} \\
 \bar{p} &= 0,79 \\
 N' &= \frac{1600(1-\bar{p})}{\bar{p}} \\
 &= \frac{1600(1-0,79)}{0,79} \\
 &= 427,72
 \end{aligned}$$

The results of the data sufficiency test for Helper 1 show that $N' < N$, indicating that the collected data are adequate and sufficient for further analysis.

d. Helper 2

$$\begin{aligned}
 \sum n &= 480 \text{ sample} \\
 \bar{p} &= 0,78 \\
 N' &= \frac{1600(1-\bar{p})}{\bar{p}}
 \end{aligned}$$

$$= \frac{1600(1-0,78)}{0,78}$$

$$= 450,27$$

The results of the data sufficiency test for Helper 2 show that $N' < N$, indicating that the collected data are adequate and sufficient for further analysis.

e. Helper 3

$$\sum n = 480 \text{ sample}$$

$$\bar{p} = 0,77$$

$$N' = \frac{1600(1-\bar{p})}{\bar{p}}$$

$$= \frac{1600(1-0,78)}{0,78}$$

$$= 464,05$$

The results of the data sufficiency test for Helper 3 show that $N' < N$, indicating that the collected data are adequate and sufficient for further analysis.

Table 5 . 4 Recapitulation of The Data Sufficiency Test

Labours	$\bar{p} = \frac{\sum p_i}{k}$	N	$N' = \frac{1600(1 - \bar{p})}{\bar{p}}$	Describe
Welder 1	0,78	480	448,00	Considered sufficient
Welder 2	0,77	480	466,36	Considered sufficient
Helper 1	0,79	480	427,72	Considered sufficient
Helper 2	0,78	480	450,27	Considered sufficient
Helper 3	0,77	480	464,05	Considered sufficient
Average			451,28	Considered sufficient

Based on the results of the data sufficiency test, it was found that $N' < N$ for all observed labours, indicating that the collected data meet the required level of statistical confidence and precision. This confirms that the number of observations is adequate to represent actual field conditions and to support further statistical analysis. Since the actual number of observations exceeds the minimum required sample size, the dataset is considered valid and reliable. The adequacy of the data ensures that variations in labour performance and site conditions have been

sufficiently captured, thereby minimizing random error and strengthening the robustness of the analysis. Therefore, the productivity results and subsequent comparisons can be confidently used as a basis for evaluating workforce performance in this study.

5.2.4 Calculate Required Observation

a. Percentage of Productives (PP)

$$PP = \frac{\text{Total Productivity}}{K} \times 100$$

Total Time Productives = 4.493 total productives from labours

K (total sample) = 12 days x 96 sample x 5 labours
= 5.760 sample

$$\begin{aligned} \text{Percentage Productives} &= \frac{4.493}{5.760} \times 100 \\ &= 78 \% \\ &= 0,78 \end{aligned}$$

b. Total Minute Productives (TPM)

$$PP = 0,78$$

$$\begin{aligned} K &= 8 \text{ (hours)} \times 60 \text{ (Minutes)} \times 12 \text{ (Days)} \\ &= 5.760 \text{ Minutes} \end{aligned}$$

$$\begin{aligned} \text{TPM} &= PP \times \text{Total Observation Time (minutes)} \\ &= 0,78 \times 5.760 \text{ minutes} \\ &= 4.493 \text{ Minutes} \end{aligned}$$

The observed product is a C25 steel pipe with a diameter of 4 inches, a thickness of 3.2 mm, and a length of 12 meters. Based on the material specification and steel density, the unit weight of the pipe is approximately 8,77 kg per meter. The materials were prefabricated and pre-cut in the factory before being delivered to the site in ready-to-install condition. From 5.760 observations (12 days × 96 samples × 5 labours), 4.493 observations were categorized as productive activities, resulting in a 78% productive work percentage with a total productive time of 4.493 minutes. The total output production based on observation measurement is presented in the following table 5.5.

Table 5 . 5 Total Unit Production Observation

Days	Productive	Non-Productive (Idle)	Volume (kg)
1	361	119	84,56
2	378	102	87,95
3	385	95	91,83
4	356	124	93,23
5	367	113	88,49
6	367	113	95,50
7	368	112	83,28
8	352	128	88,51
9	366	114	91,28
10	402	78	80,93
11	398	82	86,10
12	393	87	75,57
Total	4493	1267	1047,23

c. Cycle Time

Cycle time represents the amount of time required to produce one unit of output. It is calculated by dividing the total production time by the total number of units produced. In this study, the total production time (TPM) was recorded as 4.493 minutes, while the total production output was 1047.23 kg. Therefore, the cycle time can be calculated as follows:

$$\text{TPM} = 4.493 \text{ Minutes}$$

$$\begin{aligned}
 \text{Cycle Time} &= \frac{\text{TPM}}{\text{Total Unit Produced}} \\
 &= \frac{4.493 \text{ minutes}}{1047,23 \text{ kg}} \\
 &= 4,30 \text{ minutes/kg}
 \end{aligned}$$

This result indicates that approximately 4,30 minutes/kg required to produce one kilogram of product under the observed production conditions.

d. Normal Time

In work study, particularly in time study analysis, calculating normal time is an important step to determine the amount of time that should reasonably be required for a labour to complete a task when performing at a normal pace. Normal time is obtained from the observed time that has been adjusted based

on the labour performance rating. In other words, the time recorded during field observations cannot be used directly instead, it must be adjusted to represent standard working conditions, normal time also assists companies in improving work efficiency, evaluating existing work methods, and establishing realistic and fair production targets for labours. The calculation of normal time not only serves to determine a reasonable working time but also becomes an important basis for decision making related to productivity and efficiency within a work process. Therefore, the normal time can be calculated as follows:

Adjustment factor	=	Skill : Good (C1)	= 0,06
	=	Effort : Good (C2)	= 0,02
	=	Condition : Excellent (B)	= 0,04
	=	Consistency : Good (C)	= 0,01
			= 0,13
			+
Normal time	=	Cycle Time x Adjustment Factor	
(standard Time)	=	4,30 x (1 - 0,13)	
	=	3,74 minute/kg	

Based on the normal time calculation results of 3,74 minute/kg the productivity of each labour in 1 day (8 working hours).

5.2.5 Calculate Labours Productivity

Based on direct observation in the field, it was found that the productivity of labour installing the steel structure at *joglo* roof was 1.047,23kg produced by 5 labours over 12 days observation. The calculating output labour productive as shown below:

Total OH Welder	=	2 labour x 12 day	=	24 OH
Welder Productives	=	$\frac{\text{Total Unit Produced}}{\text{Total OH}}$	=	$\frac{1.047,23}{24} = 43,64 \text{ kg/day}$

$$\text{Total OH Helper} = 3 \text{ labour} \times 12 \text{ day} = 36 \text{ OH}$$

$$\text{Helper Productives} = \frac{\text{Total Unit Produced}}{\text{Total OH}} = \frac{1.047,23}{36} = 29,08 \text{ kg/day}$$

In conclusion, the total Man Hours (OH) for welders amounted to 24OH, calculated from 2 labours over 12 working days. Based on the total production output of 1.047,23 kg, the welder productive rate was determined to be 43,64 kg/day. Meanwhile, the total man-hours for helpers reached 36 OH, derived from 3 labours over 12 working days. Using the same total production output, the helper productive rate was calculated at 29,08 kg/day. These results indicate that welders demonstrate a higher productive level compared to helpers, which is consistent with their primary role in the welding process and direct contribution to production output.

5.3 Productivity Calculations According to SE DJB No 182/SE/Dk/2025.

According to The SE DJB No 182/SE/Dk/2025 concerning the analysis of unit prices for steel frame installation work, the following unit price indices are presented. Table 3.1 presents the Unit Price Analysis (AHS) for steel fabrication and erection work expressed per 1 kilogram of output. This analysis is used to determine the required labour, materials, and equipment necessary to produce 1 kg of installed steel in the field.

In the benchmark (SE DJB No182/SE/Dk/2025) it is explained that the technical requirements for calculating the unit price of steel roof structure are as follows:

- a. The calculation of work units must be based on technical drawing and work plans (RKS).
- b. The indirect index is set at 10 - 15% of direct costs.
- c. Effective working hours for labourers are calculated as 8 hours per day, consisting of 7 hours of effective working time with a maximum break time of 1 hour.

presents from Table 3.1 the calculated daily output of the work team:

$$\begin{aligned}
 \text{Helper} &= 0,0375 \text{ OH} \\
 &= \frac{1 \text{ kg}}{0,0375} = 26,67 \text{ kg/OH} \\
 \text{Welder} &= 0,0125 \text{ OH} \\
 &= \frac{1 \text{ kg}}{0,0125} = 80 \text{ kg/OH}
 \end{aligned}$$

5.4 Comparison of Labour Productivity Between Field Productivity and Productivity of SE DJB No 182/SE/Dk/2025

When compared with the productivity standards established in SEDJB No. 182/SE/Dk/2025 which specify a standard of 80 kg/day for welders and 26,67 kg/day for helpers the observed helper productivity slightly exceeds the reference value. Meanwhile, productivity for welder on field is 43,63 kg/day and helpers achieved 29,08 kg/day remains below the stated benchmark, reaching approximately 54,5% of the standard. This difference may reflect operational conditions encountered on site, such as coordination factors, material readiness, or workflow arrangements, which present opportunities for further improvement and optimization.

5.5 Discussion

After conducting observations for 12 days involving five labourers consisting of two welders and three helpers assigned to the steel roof frame installation of the *Joglo* structure at the Gelanggang Inovasi dan Kreativitas (GIK) Universitas Gadjah Mada, a total of 5.760 data points were obtained (12 days $\times$ 96 samples $\times$ 5 labourers). The average labour productivity shows that welders achieved 43.63 kg/day, whereas helpers achieved 29,08 kg/day. This result indicates that welder productivity is approximately 1,5 times higher than that of helpers, which generally reflects the differences in responsibilities and skill levels required in the steel roof installation process. Therefore, the work performance in the steel roof installation process can be considered stable, with no significant deviations occurring during the observation period. This stability productivity data obtained is reliable and representative of the actual field conditions. Based on the calculated values of the Upper Control Limit (UCL) and Lower Control Limit (LCL), To visualize the

distribution of productive working time during the observation period, the following control chart is presented :

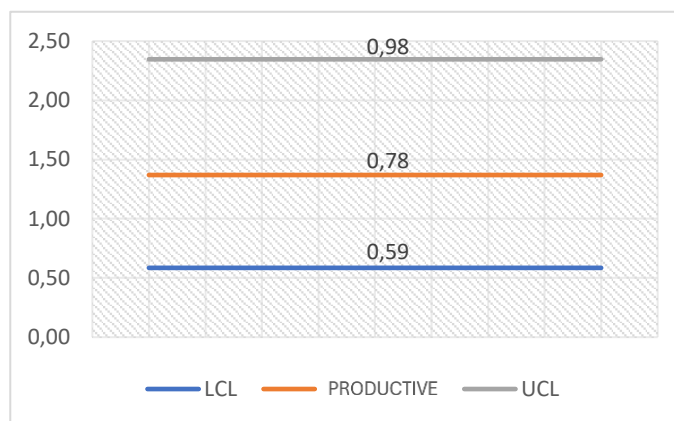


Figure 5 . 1 Control Graph Labours

Based on Figure 5.1 the control chart analysis indicates that the average field productive of 0,78 lies between the Lower Control Limit 0,59 and the Upper Control Limit 0,98. This indicates that the productivity level during the observation period remained within the statistical control limits.

In addition, the data sufficiency test resulted in a value of 451,28 indicating that the number of observations collected in this study was adequate for productivity analysis. This result confirms that the observation data are statistically sufficient and representative of the actual field conditions. However, differences between field productivity and standard values may be influenced by several internal and external factors affecting labour productivity, including labour skills, weather conditions such as rainfall during the observation period, material availability, supervision quality, and managerial capacity, as identified by Afrian et al. (2024).

The recapitulation of the uniformity calculation results is presented in the following table.

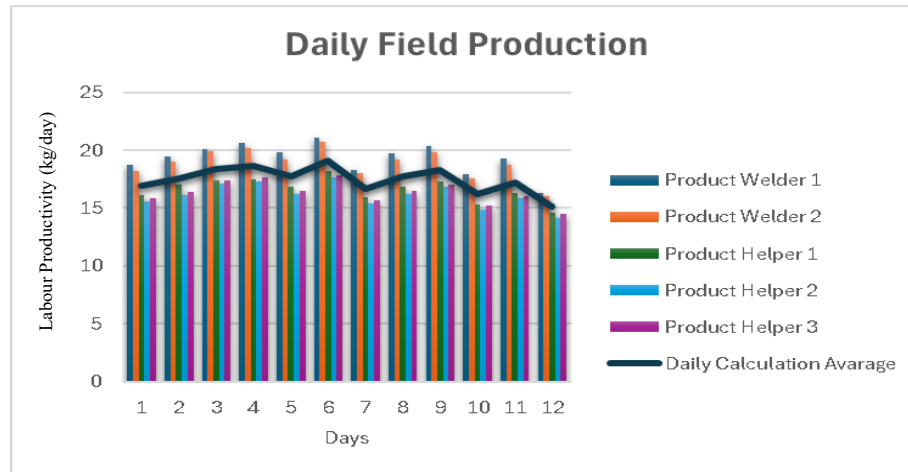


Figure 5 . 2 Graphic Daily Field Production

Based on the Work Sampling calculation, the standard time value was 4,30 minutes/kg, while the normal time was 3,74 minutes/kg, resulting in an average daily labour productivity of 17,45 kg/OH. The Daily Field Production graph illustrates that labour productivity fluctuated during the 12 day observation period, with productivity values generally ranging between approximately 15 kg/OH and 21 kg/OH. Although the overall productivity trend appears relatively stable, several noticeable increases and decreases occurred across the observation days. According to Nadhim et al. (2023), such variations indicate that field productivity is dynamic and influenced by several operational and human related factors rather than remaining constant throughout the working period. One possible factor explaining these fluctuations is the labour level of experience as well as weather conditions during the observation period. In addition, high workload intensity may affect labour endurance and concentration, which can eventually influence productivity levels over time. Furthermore, the differences in productivity between welders and helpers observed in the graph may be associated with task specialization and work complexity. Welders is typically responsible for the core technical activities, whereas helpers perform supporting tasks. Consequently, variations in productivity

output may arise due to differences in task difficulty and the level of skill required. This finding is consistent with the study by Wicaksono et al. (2023), which reported that productivity values vary significantly depending on the type of work performed. Considering the fluctuations and variations in labour productivity observed during the field activities, it is important to further evaluate how the obtained productivity values compare with the established national productivity standards. Therefore, a comparison between field labour productivity and the productivity standards stated in SE DJB No. 182/SE/DK/2025 is presented in the following graph:

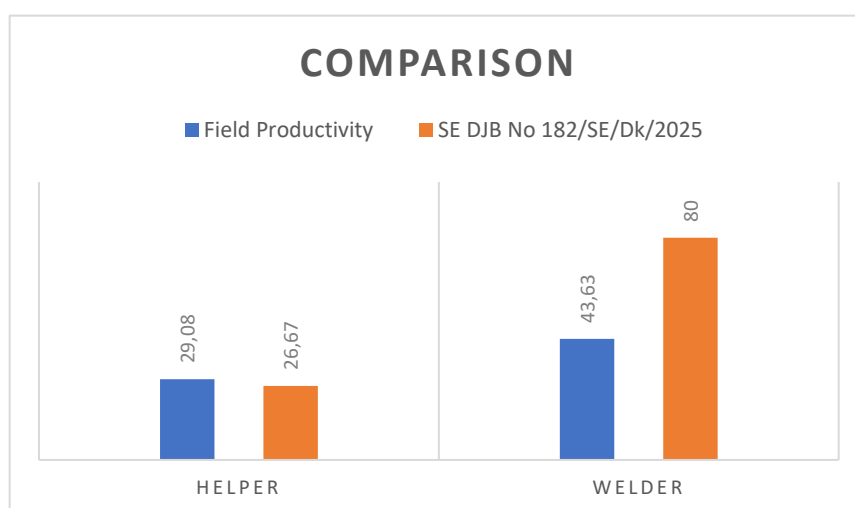


Figure 5 . 3 Comparison the productivity of steel roof frame installers according to SE DJB No 182/SE/Dk/2025.

The comparison shows that helper field productivity 29,08 kg/day slightly exceeds the standard 26,67 kg/day, indicating efficient performance. In contrast, welder field productivity 43,63 kg/day is significantly lower than the standard 80 kg/day. This gap suggests inefficiencies in welding activities, requiring further evaluation to improve performance and achieve the expected productivity level. However, variations between field productivity and standard values may be influenced by several internal and external factors, such as labour skills, weather conditions, material availability, supervision quality, and managerial capacity.

CHAPTER VI

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Based on the results of the analysis and discussion obtained in the previous chapter, the following conclusions can be drawn:

1. Based on 12 days of observation involving five labours in the installation of the *Joglo* steel roof structure at Universitas Gadjah Mada, a total of 5.760 data points were obtained and analysed using the Five Minutes Rate method. The results show that the productivity control limits were within an average Lower Control Limit (LCL) of 0,58 and Upper Control Limit (UCL) of 0,97 with an average field productivity value of 0,78. Based on the work sampling calculation, the standard time was 4,30 minutes/kg and the normal time was 3,74 minutes/kg. The average labour productivity was 43,63 kg/day for welders and 29,08 kg/day for helpers. In addition, the data sufficiency test value of 451,28 indicates that the number of observations was adequate and statistically representative.
2. Second, when compared with the productivity standards stipulated in the Circular Letter of the Director General of Construction Development Number 182/SE/DK/2025, the helper productivity rate of 29,08 kg/day slightly exceeds the benchmark value of 26,67 kg/day. In contrast, the field productivity of welders, recorded at 43,63 kg/day, is significantly lower than the standard value of 80 kg/day.

6.2 Recommendation

After observing and analysing the data, there are several things that should be considered for future research. Specific attention should be given to improving the performance of helper personnel. This can be achieved through targeted training programs, clearer task distribution, and improved supervision to ensure that helpers can effectively support the primary work processes, it is recommended to conduct regular evaluations and monitoring of workforce productivity to identify performance gaps and implement corrective actions in a timely manner.

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APPENDICES

Appendix 1 Observation Data Labour Productivity in the Field for Day 1

Monday, 13 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
1	08:00		v		v	v		v		v		Work Time
2	08:05		v		v	v		v		v		
3	08:10		v		v	v		v		v		
4	08:15		v	v		v		v		v		
5	08:20		v	v		v		v		v		
6	08:25	v		v		v		v		v		
7	08:30	v		v		v		v		v		
8	08:35	v		v		v		v		v		
9	08:40	v		v			v		v		v	
10	08:45	v		v		v		v		v		
11	08:50	v		v		v		v		v		
12	08:55	v		v		v		v		v		
13	09:00	v		v		v		v		v		
14	09:05	v		v		v		v		v		
15	09:10	v		v		v		v		v		
16	09:15	v		v		v		v		v		
17	09:20	v		v		v		v		v		
18	09:25	v		v		v		v		v		
19	09:30	v		v		v		v		v		
20	09:35	v		v		v		v		v		
21	09:40	v		v		v		v		v		
22	09:45	v		v		v		v		v		
23	09:50	v		v		v		v		v		
24	09:55	v		v		v		v		v		
25	10:00		v	v		v		v		v		
26	10:05	v		v		v		v		v		
27	10:10	v		v		v		v		v		
28	10:15	v			v	v		v		v		
29	10:20	v		v		v		v		v		
30	10:25	v			v	v		v		v		
31	10:30	v		v		v		v		v		
32	10:35	v		v			v		v		v	
33	10:40	v		v			v		v		v	
34	10:45	v		v		v		v		v		
35	10:50	v		v		v		v		v		
36	10:55	v		v		v		v		v		

Monday, 13 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
37	11:00	v		v		v		v		v		
38	11:05	v		v		v		v		v		
39	11:10		v	v		v		v		v		
40	11:15	v		v		v		v		v		
41	11:20	v		v		v		v		v		
42	11:25	v		v		v		v		v		
43	11:30	v		v		v		v		v		
44	11:35	v		v		v		v		v		
45	11:40	v		v		v		v		v		
46	11:45	v		v			v		v		v	
47	11:50	v		v			v		v		v	
48	11:55		v		v		v		v		v	
49	12:00		v		v		v		v		v	
50	12:05		v		v		v		v		v	
51	12:10		v		v		v		v		v	
52	12:15		v		v		v		v		v	
53	12:20		v		v		v		v		v	
54	12:25		v		v		v		v		v	
55	12:30		v		v		v		v		v	
56	12:35		v		v		v		v		v	
57	12:40		v		v		v		v		v	
58	12:45		v		v		v		v		v	
59	12:50		v		v		v		v		v	
60	12:55		v		v		v		v		v	
61	13:00		v		v		v		v		v	
62	13:05		v		v		v		v		v	
63	13:10	v		v			v		v		v	
64	13:15	v		v			v		v		v	
65	13:20	v		v			v		v		v	
66	13:25	v		v			v		v		v	
67	13:30	v		v			v		v		v	
68	13:35	v		v		v		v		v		
69	13:40	v		v		v		v		v		
70	13:45	v		v		v		v		v		
71	13:50	v		v		v		v		v		
72	13:55	v		v		v		v		v		
73	14:00	v		v		v		v		v		
74	14:05	v		v		v		v		v		

Monday, 13 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
75	14:10	v		v		v		v		v		
76	14:15	v		v		v		v		v		
77	14:20	v		v		v		v		v		
78	14:25		v		v	v		v		v		
79	14:30	v		v		v		v		v		
80	14:35	v		v		v		v		v		
81	14:40	v		v		v		v		v		
82	14:45	v		v		v		v		v		
83	14:50	v		v		v		v		v		
84	14:55	v		v		v		v		v		
85	15:00	v		v		v		v		v		
86	15:05	v		v		v		v		v		
87	15:10	v		v		v		v		v		
88	15:15	v		v		v		v		v		
89	15:20	v		v		v		v		v		
90	15:25	v		v		v		v		v		
91	15:30	v		v		v		v		v		
92	15:35	v		v		v		v		v		
93	15:40	v		v		v		v		v		
94	15:45	v		v		v		v		v		
95	15:50	v		v		v		v		v		
96	15:55	v		v		v		v		v		
Total		73	23	75	21	71	25	71	25	71	25	
Total Time Productive		361										
Total Time Idle		119										
Volume Produced (kg)		84,56										

Appendix 2 Observation Data Labour Productivity in the Field for Day 2

Tuesday, 14 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
1	08:00	v		v		v		v		v		Work Time
2	08:05	v		v		v		v		v		
3	08:10	v		v		v		v		v		
4	08:15	v		v		v		v		v		
5	08:20	v		v		v		v		v		
6	08:25	v		v		v		v		v		
7	08:30	v		v		v		v		v		
8	08:35	v		v		v		v		v		
9	08:40	v		v		v		v		v		
10	08:45	v		v		v		v		v		
11	08:50	v		v		v		v		v		
12	08:55	v		v		v		v		v		
13	09:00	v		v		v		v		v		
14	09:05	v		v		v		v		v		
15	09:10	v		v		v		v		v		
16	09:15	v		v		v		v		v		
17	09:20		v	v		v		v		v		
18	09:25		v	v		v		v		v		
19	09:30		v	v		v		v		v		
20	09:35	v		v		v		v		v		
21	09:40	v		v		v		v		v		
22	09:45	v		v		v		v		v		
23	09:50	v		v		v		v		v		
24	09:55	v		v		v		v		v		
25	10:00	v		v		v		v		v		
26	10:05	v		v		v		v		v		
27	10:10	v		v		v		v		v		
28	10:15	v		v			v		v		v	
29	10:20	v		v			v		v		v	
30	10:25	v		v		v		v		v		
31	10:30	v		v		v		v		v		
32	10:35		v	v		v		v		v		
33	10:40		v	v		v		v		v		
34	10:45	v		v		v		v		v		
35	10:50	v			v	v		v		v		
36	10:55	v			v	v		v		v		

Tuesday, 14 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
37	11:00	v		v		v		v		v		
38	11:05	v		v		v		v		v		
39	11:10	v		v		v		v		v		
40	11:15	v		v		v		v		v		
41	11:20	v		v		v		v		v		
42	11:25	v		v		v		v		v		
43	11:30	v		v		v		v		v		
44	11:35	v		v		v		v		v		
45	11:40	v		v		v		v		v		
46	11:45	v		v		v		v		v		
47	11:50	v			v		v		v		v	
48	11:55	v			v		v		v		v	
49	12:00		v		v	v		v		v		
50	12:05		v		v		v		v		v	
51	12:10		v		v		v		v		v	
52	12:15		v		v		v		v		v	
53	12:20		v		v		v		v		v	
54	12:25		v		v		v		v		v	
55	12:30		v		v		v		v		v	
56	12:35		v		v		v		v		v	
57	12:40		v		v		v		v		v	
58	12:45		v		v		v		v		v	
59	12:50		v		v		v		v		v	
60	12:55		v		v		v		v		v	
61	13:00		v	v			v		v		v	
62	13:05		v	v			v		v		v	
63	13:10		v	v			v		v		v	
64	13:15	v		v		v		v		v		
65	13:20	v		v		v		v		v		
66	13:25	v		v		v		v		v		
67	13:30	v		v		v		v		v		
68	13:35	v		v		v		v		v		
69	13:40	v		v		v		v		v		
70	13:45	v		v		v		v		v		
71	13:50	v		v		v		v		v		
72	13:55	v		v		v		v		v		
73	14:00	v		v		v		v		v		

Tuesday, 14 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
74	14:05	v		v			v		v		v	
75	14:10	v		v			v		v		v	
76	14:15	v		v		v		v		v		
77	14:20	v		v		v		v		v		
78	14:25	v		v		v		v		v		
79	14:30	v		v		v		v		v		
80	14:35	v			v	v		v		v		
81	14:40	v			v	v		v		v		
82	14:45	v		v		v		v		v		
83	14:50	v		v		v		v		v		
84	14:55	v		v		v		v		v		
85	15:00	v		v		v		v		v		
86	15:05	v		v		v		v		v		
87	15:10	v		v		v		v		v		
88	15:15	v		v		v		v		v		
89	15:20	v		v		v		v		v		
90	15:25	v		v		v		v		v		
91	15:30	v		v		v		v		v		
92	15:35	v		v		v		v		v		
93	15:40	v			v	v		v		v		
94	15:45	v			v	v		v		v		
95	15:50	v			v	v		v		v		
96	15:55	v			v	v		v		v		
Total		76	20	74	22	76	20	76	20	76	20	
Total Time Productive		378										
Total Time Idle		102										
Volume Produced (kg)		87,95										

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
1	08:00	v		v			v		v		v	
2	08:05	v		v		v		v		v		
3	08:10	v		v		v		v		v		
4	08:15	v		v		v		v		v		
5	08:20	v		v		v		v		v		
6	08:25	v		v		v		v		v		
7	08:30	v		v		v		v		v		
8	08:35	v		v		v		v		v		
9	08:40	v		v		v		v		v		
10	08:45	v		v		v		v		v		
11	08:50	v		v		v		v		v		
12	08:55	v		v		v		v		v		
13	09:00	v		v		v		v		v		
14	09:05	v		v		v		v		v		
15	09:10	v		v		v		v		v		
16	09:15	v		v		v		v		v		
17	09:20	v		v		v		v		v		
18	09:25	v		v		v		v		v		
19	09:30	v		v		v		v		v		
20	09:35	v		v		v		v		v		
21	09:40	v		v		v		v		v		
22	09:45	v		v		v		v		v		
23	09:50	v			v	v		v		v		
24	09:55		v		v	v		v		v		
25	10:00		v	v		v		v		v		
26	10:05		v	v		v		v		v		
27	10:10	v		v		v		v		v		
28	10:15	v		v		v		v		v		
29	10:20	v		v		v		v		v		
30	10:25	v		v		v		v		v		
31	10:30	v		v		v		v		v		
32	10:35	v		v		v		v		v		
33	10:40	v		v		v		v		v		
34	10:45	v		v		v		v		v		
35	10:50	v		v		v		v		v		
36	10:55	v		v		v		v		v		

Wednesday, 15 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
37	11:00	v		v		v		v		v		
38	11:05	v		v		v		v		v		
39	11:10	v		v		v		v		v		
40	11:15	v		v		v		v		v		
41	11:20	v		v		v		v		v		
42	11:25	v		v		v		v		v		
43	11:30	v		v		v		v		v		
44	11:35	v		v		v		v		v		
45	11:40	v		v		v		v		v		
46	11:45	v		v		v		v		v		
47	11:50	v			v	v		v		v		
48	11:55		v		v	v		v		v		
49	12:00		v		v	v		v		v		
50	12:05		v		v		v		v		v	
51	12:10		v		v		v		v		v	
52	12:15		v		v		v		v		v	
53	12:20		v		v		v		v		v	
54	12:25		v		v		v		v		v	
55	12:30		v		v		v		v		v	
56	12:35		v		v		v		v		v	
57	12:40		v		v		v		v		v	
58	12:45		v		v		v		v		v	
59	12:50		v		v		v		v		v	
60	12:55	v			v		v		v		v	
61	13:00	v		v			v		v		v	
62	13:05	v		v			v		v		v	
63	13:10	v		v			v		v		v	
64	13:15	v		v		v		v		v		
65	13:20	v		v		v		v		v		
66	13:25	v		v		v		v		v		
67	13:30	v		v		v		v		v		
68	13:35	v		v		v		v		v		
69	13:40	v		v		v		v		v		
70	13:45	v		v		v		v		v		
71	13:50	v		v		v		v		v		
72	13:55	v		v		v		v		v		
73	14:00	v		v		v		v		v		
74	14:05	v		v		v		v		v		

Appendix 4 Observation Data Labour Productivity in the Field for Day 4

Thursday, 16 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
1	08:00		v		v		v		v		v	Work Time
2	08:05		v		v		v		v		v	
3	08:10		v		v		v		v		v	
4	08:15		v		v		v		v		v	
5	08:20	v		v		v		v		v		
6	08:25	v		v		v		v		v		
7	08:30	v		v		v		v		v		
8	08:35	v		v		v		v		v		
9	08:40	v		v		v		v		v		
10	08:45	v		v		v		v		v		
11	08:50	v		v		v		v		v		
12	08:55	v		v		v		v		v		
13	09:00	v		v		v		v		v		
14	09:05	v		v		v		v		v		
15	09:10	v		v		v		v		v		
16	09:15	v		v		v		v		v		
17	09:20	v		v		v		v		v		
18	09:25		v	v		v		v		v		
19	09:30		v	v		v		v		v		
20	09:35	v		v		v		v		v		
21	09:40	v		v		v		v		v		
22	09:45	v		v		v		v		v		
23	09:50	v		v		v		v		v		
24	09:55	v		v		v		v		v		
25	10:00	v		v		v		v		v		
26	10:05	v		v		v		v		v		
27	10:10	v		v		v		v		v		
28	10:15	v		v			v		v		v	
29	10:20	v		v			v		v		v	
30	10:25	v		v		v		v		v		
31	10:30	v		v		v		v		v		
32	10:35	v		v		v		v		v		
33	10:40	v		v		v		v		v		
34	10:45	v		v		v		v		v		
35	10:50	v			v	v		v		v		
36	10:55	v			v	v		v		v		

Thursday, 16 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
37	11:00	v			v	v		v		v		
38	11:05	v		v		v		v		v		
39	11:10	v		v		v		v		v		
40	11:15	v		v		v		v		v		
41	11:20	v		v		v		v		v		
42	11:25	v		v		v		v		v		
43	11:30	v		v		v		v		v		
44	11:35	v		v		v		v		v		
45	11:40	v		v		v		v		v		
46	11:45	v		v		v		v		v		
47	11:50	v			v		v		v		v	
48	11:55	v			v		v		v		v	
49	12:00	v			v		v		v		v	
50	12:05	v			v		v		v		v	
51	12:10		v		v		v		v		v	
52	12:15		v		v		v		v		v	
53	12:20		v		v		v		v		v	
54	12:25		v		v		v		v		v	
55	12:30		v		v		v		v		v	
56	12:35		v		v		v		v		v	
57	12:40		v		v		v		v		v	
58	12:45		v		v		v		v		v	
59	12:50		v		v		v		v		v	
60	12:55		v		v		v		v		v	
61	13:00		v	v			v		v		v	
62	13:05		v	v			v		v		v	
63	13:10		v	v			v		v		v	
64	13:15	v		v		v		v		v		
65	13:20	v		v		v		v		v		
66	13:25	v		v		v		v		v		
67	13:30	v		v		v		v		v		
68	13:35	v		v		v		v		v		
69	13:40	v		v		v		v		v		
70	13:45	v		v		v		v		v		
71	13:50	v		v		v		v		v		
72	13:55	v		v		v		v		v		
73	14:00	v		v		v		v		v		
74	14:05	v		v			v		v		v	

Thursday, 16 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
75	14:10	v		v			v		v		v	
76	14:15	v		v		v		v		v		
77	14:20	v		v		v		v		v		
78	14:25	v		v		v		v		v		
79	14:30	v		v		v		v		v		
80	14:35		v		v	v		v		v		
81	14:40		v		v	v		v		v		
82	14:45	v		v		v		v		v		
83	14:50	v		v		v		v		v		
84	14:55	v		v		v		v		v		
85	15:00	v		v		v		v		v		
86	15:05	v		v		v		v		v		
87	15:10	v		v		v		v		v		
88	15:15	v		v		v		v		v		
89	15:20	v		v		v		v		v		
90	15:25	v		v		v		v		v		
91	15:30	v		v		v		v		v		
92	15:35	v		v		v		v		v		
93	15:40	v			v	v		v		v		
94	15:45	v			v	v		v		v		
95	15:50	v			v	v		v		v		
96	15:55		v		v	v		v		v		
Total		74	22	69	27	71	25	71	25	71	25	
Total Time Productive		356										
Total Time Idle		124										
Volume Produced (kg)		93,23										

Appendix 5 Observation Data Labour Productivity in the Field for Day 5

Friday, 17 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
1	08:00		v		v		v		v	v		Work Time
2	08:05		v	v			v		v	v		
3	08:10	v		v			v		v	v		
4	08:15	v		v		v		v		v		
5	08:20	v			v	v		v		v		
6	08:25	v			v	v		v		v		
7	08:30	v			v	v		v		v		
8	08:35	v			v		v		v	v		
9	08:40	v		v			v		v		v	
10	08:45	v		v		v		v		v		
11	08:50	v		v		v		v		v		
12	08:55	v		v		v		v		v		
13	09:00	v		v		v		v		v		
14	09:05	v		v			v		v	v		
15	09:10	v		v			v		v	v		
16	09:15	v		v		v		v		v		
17	09:20	v		v		v		v		v		
18	09:25	v		v		v		v		v		
19	09:30	v		v		v		v		v		
20	09:35	v		v		v		v		v		
21	09:40	v		v		v		v		v		
22	09:45	v		v		v		v		v		
23	09:50	v		v		v		v		v		
24	09:55	v		v		v		v		v		
25	10:00	v		v		v		v		v		
26	10:05	v		v		v		v		v		
27	10:10	v		v		v		v		v		
28	10:15	v		v		v		v		v		
29	10:20	v		v		v		v		v		
30	10:25	v		v		v		v		v		
31	10:30	v		v		v		v		v		
32	10:35	v		v		v		v			v	
33	10:40	v		v		v		v			v	
34	10:45	v		v		v		v		v		
35	10:50	v		v		v		v		v		
36	10:55	v		v		v		v		v		

Friday, 17 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
37	11:00	v		v		v		v		v		
38	11:05	v		v		v		v		v		
39	11:10	v		v		v		v		v		
40	11:15	v		v		v		v		v		
41	11:20	v		v		v		v		v		
42	11:25	v		v		v		v		v		
43	11:30		v	v		v		v		v		
44	11:35		v	v		v		v		v		
45	11:40		v	v		v		v		v		
46	11:45		v	v		v		v			v	
47	11:50		v	v		v		v			v	
48	11:55		v	v		v		v			v	
49	12:00		v		v	v		v			v	
50	12:05		v		v	v		v			v	
51	12:10		v		v	v		v			v	
52	12:15		v		v	v		v			v	
53	12:20		v		v		v		v		v	
54	12:25		v		v		v		v		v	
55	12:30		v		v		v		v		v	
56	12:35		v		v		v		v		v	
57	12:40		v		v		v		v		v	
58	12:45		v		v		v		v		v	
59	12:50		v		v		v		v		v	
60	12:55	v			v		v		v		v	
61	13:00	v			v		v		v		v	
62	13:05	v			v		v		v		v	
63	13:10	v			v	v		v			v	
64	13:15	v			v	v		v			v	
65	13:20	v		v		v		v			v	
66	13:25	v		v		v		v			v	
67	13:30	v		v		v		v			v	
68	13:35	v		v		v		v		v		
69	13:40	v		v		v		v		v		
70	13:45		v	v		v		v		v		
71	13:50		v	v		v		v		v		
72	13:55	v		v		v		v		v		
73	14:00	v		v		v		v		v		

Friday, 17 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
74	14:05	v		v		v		v		v		
75	14:10	v		v		v		v		v		
76	14:15	v		v		v		v		v		
77	14:20	v		v		v		v		v		
78	14:25	v		v		v		v		v		
79	14:30	v		v		v		v		v		
80	14:35	v		v		v		v		v		
81	14:40	v		v		v		v		v		
82	14:45	v		v		v		v		v		
83	14:50	v			v	v		v		v		
84	14:55	v			v	v		v		v		
85	15:00	v			v	v		v		v		
86	15:05	v			v	v		v		v		
87	15:10	v		v		v		v		v		
88	15:15	v		v		v		v		v		
89	15:20		v	v		v		v		v		
90	15:25		v	v		v		v		v		
91	15:30		v	v		v		v		v		
92	15:35		v	v		v		v		v		
93	15:40		v	v		v		v		v		
94	15:45		v	v		v		v		v		
95	15:50		v	v		v		v		v		
96	15:55		v	v		v		v		v		
Total		67	29	71	25	79	17	79	17	71	25	
Total Time Productive		367										
Total Time Idle		113										
Volume Produced (kg)		88,49										

Appendix 6 Observation Data Labour Productivity in the Field for Day 6

Saturday, 18 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
1	08:00		v		v		v		v		v	Work Time
2	08:05	v			v		v		v		v	
3	08:10	v		v			v		v		v	
4	08:15	v		v		v			v	v		
5	08:20	v		v		v			v	v		
6	08:25		v		v	v		v		v		
7	08:30	v		v		v		v		v		
8	08:35	v		v		v		v		v		
9	08:40	v		v		v		v		v		
10	08:45	v		v		v		v		v		
11	08:50	v		v		v		v		v		
12	08:55	v		v		v		v		v		
13	09:00	v		v		v		v		v		
14	09:05	v		v		v		v		v		
15	09:10	v		v		v		v		v		
16	09:15	v		v		v		v		v		
17	09:20	v		v		v		v		v		
18	09:25	v		v		v		v		v		
19	09:30	v		v		v		v		v		
20	09:35	v		v		v		v		v		
21	09:40	v		v		v		v		v		
22	09:45	v		v		v		v		v		
23	09:50	v		v		v		v		v		
24	09:55	v		v		v		v		v		
25	10:00	v		v		v			v	v		
26	10:05	v		v		v		v		v		
27	10:10	v		v		v		v		v		
28	10:15	v		v			v	v			v	
29	10:20	v		v			v	v			v	
30	10:25	v		v		v		v		v		
31	10:30	v		v		v		v		v		
32	10:35		v	v		v		v		v		
33	10:40		v	v		v		v		v		
34	10:45	v		v		v		v		v		
35	10:50	v		v		v		v		v		
36	10:55	v		v		v		v		v		

Saturday, 18 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
37	11:00	v		v		v		v		v		
38	11:05	v		v		v		v		v		
39	11:10	v		v		v			v	v		
40	11:15	v		v		v		v		v		
41	11:20	v		v		v		v		v		
42	11:25	v		v		v		v		v		
43	11:30	v		v		v		v		v		
44	11:35	v		v		v		v		v		
45	11:40	v		v		v		v		v		
46	11:45	v		v		v		v		v		
47	11:50	v			v		v	v			v	Break time
48	11:55	v			v		v		v		v	
49	12:00		v		v	v			v	v		
50	12:05		v		v		v		v		v	
51	12:10		v		v		v		v		v	
52	12:15		v		v		v		v		v	
53	12:20		v		v		v		v		v	
54	12:25		v		v		v		v		v	
55	12:30		v		v		v		v		v	
56	12:35		v		v		v		v		v	
57	12:40		v		v		v		v		v	
58	12:45		v		v		v		v		v	
59	12:50		v		v		v		v		v	
60	12:55		v		v		v		v		v	
61	13:00		v	v			v		v		v	Work Time
62	13:05		v	v			v		v		v	
63	13:10		v	v			v	v			v	
64	13:15	v		v		v		v		v		
65	13:20	v		v		v		v		v		
66	13:25	v		v		v		v		v		
67	13:30	v		v		v		v		v		
68	13:35	v		v		v		v		v		
69	13:40	v		v		v		v		v		
70	13:45	v		v		v		v		v		
71	13:50	v		v		v		v		v		
72	13:55	v		v		v		v		v		
73	14:00	v		v		v		v		v		
74	14:05	v		v			v	v			v	

Saturday, 18 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
75	14:10	v		v			v	v			v	
76	14:15	v		v		v		v		v		
77	14:20	v		v		v		v		v		
78	14:25	v		v		v			v	v		
79	14:30	v		v		v		v		v		
80	14:35		v		v	v		v		v		
81	14:40		v		v	v		v		v		
82	14:45	v		v		v		v		v		
83	14:50	v		v		v		v		v		
84	14:55	v		v		v		v		v		
85	15:00	v		v		v		v		v		
86	15:05	v		v		v		v		v		
87	15:10	v		v		v		v		v		
88	15:15	v		v		v		v		v		
89	15:20	v		v		v		v		v		
90	15:25	v		v		v		v		v		
91	15:30	v		v		v		v		v		
92	15:35	v		v		v		v		v		
93	15:40	v		v		v		v		v		
94	15:45	v		v		v		v		v		
95	15:50		v		v	v		v		v		
96	15:55		v		v	v		v		v		
Total		73	23	75	21	73	23	73	23	73	23	
Total Time Productive		367										
Total Time Idle		113										
Volume Produced (kg)		95,50										

Appendix 7 Observation Data Labour Productivity in the Field for Day 7

Monday, 20 March 2023

No	Time	Labours										Notes	
		welder				Helper							
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3			
		P	I	P	I	P	I	P	I	P	I		
1	08:00		v		v		v	v			v	Work Time	
2	08:05		v		v		v	v			v		
3	08:10		v		v		v	v			v		
4	08:15		v		v		v	v			v		
5	08:20		v		v		v	v			v		
6	08:25	v		v		v		v		v			
7	08:30	v		v		v			v				
8	08:35	v		v		v			v				
9	08:40	v		v		v				v	v		
10	08:45	v		v		v			v		v		
11	08:50	v		v				v		v			v
12	08:55	v		v		v		v		v			
13	09:00	v		v		v		v		v			
14	09:05	v		v		v		v		v			
15	09:10	v		v		v		v		v			
16	09:15	v		v		v		v		v			
17	09:20	v		v		v		v		v			
18	09:25	v		v		v		v		v			
19	09:30	v		v		v		v		v			
20	09:35	v		v		v		v		v			
21	09:40	v		v		v		v		v			
22	09:45	v		v		v		v		v			
23	09:50	v			v	v		v		v			
24	09:55		v		v	v		v		v			
25	10:00		v	v		v		v			v		
26	10:05		v	v		v		v		v			
27	10:10	v		v		v		v		v			
28	10:15	v		v		v		v		v			
29	10:20	v		v		v		v		v			
30	10:25	v		v		v		v		v			
31	10:30	v		v		v		v		v			
32	10:35	v		v		v			v	v			
33	10:40	v		v		v			v	v			
34	10:45	v		v		v		v		v			
35	10:50	v		v		v		v		v			
36	10:55	v		v		v		v		v			

Monday, 20 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
37	11:00	v		v		v		v		v		
38	11:05	v		v		v		v		v		
39	11:10	v		v		v		v			v	
40	11:15	v		v		v		v		v		
41	11:20	v		v		v		v		v		
42	11:25	v		v		v		v		v		
43	11:30	v		v		v		v		v		
44	11:35	v		v		v		v		v		
45	11:40	v		v		v		v		v		
46	11:45	v		v		v			v	v		
47	11:50	v			v	v			v	v		
48	11:55		v		v	v			v		v	
49	12:00		v		v	v			v		v	
50	12:05		v		v		v		v		v	
51	12:10		v		v		v		v		v	
52	12:15		v		v		v		v		v	
53	12:20		v		v		v		v		v	
54	12:25		v		v		v		v		v	
55	12:30		v		v		v		v		v	
56	12:35		v		v		v		v		v	
57	12:40		v		v		v		v		v	
58	12:45		v		v		v		v		v	
59	12:50		v		v		v		v		v	
60	12:55	v			v		v		v		v	
61	13:00	v		v			v		v		v	
62	13:05	v		v			v		v		v	
63	13:10	v		v			v		v	v		
64	13:15	v		v		v			v	v		
65	13:20	v		v		v			v	v		
66	13:25	v		v		v			v	v		
67	13:30	v		v		v			v	v		
68	13:35	v		v		v		v		v		
69	13:40	v		v		v		v		v		
70	13:45	v		v		v		v		v		
71	13:50	v		v		v		v		v		
72	13:55	v		v		v		v		v		
73	14:00	v		v		v		v		v		

Monday, 20 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
74	14:05	v		v		v		v		v		
75	14:10	v		v		v		v		v		
76	14:15	v		v		v		v		v		
77	14:20	v		v		v		v		v		
78	14:25	v		v		v		v			v	
79	14:30	v		v		v		v		v		
80	14:35	v			v	v		v		v		
81	14:40	v			v	v		v		v		
82	14:45	v		v		v		v		v		
83	14:50	v		v		v		v		v		
84	14:55	v		v		v		v		v		
85	15:00		v	v		v		v		v		
86	15:05		v	v		v		v		v		
87	15:10	v		v		v		v		v		
88	15:15	v		v		v		v		v		
89	15:20	v		v		v		v		v		
90	15:25	v		v		v		v		v		
91	15:30	v		v		v		v		v		
92	15:35	v		v		v		v		v		
93	15:40	v		v		v		v		v		
94	15:45	v		v		v		v		v		
95	15:50	v		v		v		v		v		
96	15:55	v		v		v		v		v		
Total		74	22	73	23	77	19	71	25	73	23	
Total Time Productive		368										
Total Time Idle		112										
Volume Produced (kg)		83,28										

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
1	08:00		v		v		v		v		v	Work Time
2	08:05	v		v			v		v		v	
3	08:10	v		v			v		v		v	
4	08:15	v		v			v		v		v	
5	08:20		v	v		v		v		v		
6	08:25	v		v		v		v		v		
7	08:30	v		v		v		v		v		
8	08:35	v		v		v		v		v		
9	08:40	v		v			v		v		v	
10	08:45	v		v		v		v		v		
11	08:50	v		v		v		v		v		
12	08:55	v		v		v		v		v		
13	09:00	v		v		v		v		v		
14	09:05	v		v		v		v		v		
15	09:10	v		v		v		v		v		
16	09:15	v		v		v		v		v		
17	09:20	v		v		v		v		v		
18	09:25	v		v		v		v		v		
19	09:30	v		v		v		v		v		
20	09:35	v		v		v		v		v		
21	09:40	v		v		v		v		v		
22	09:45	v		v		v		v		v		
23	09:50	v		v		v		v		v		
24	09:55	v		v		v		v		v		
25	10:00		v	v		v		v		v		
26	10:05	v		v		v		v		v		
27	10:10	v		v		v		v		v		
28	10:15	v			v	v		v		v		
29	10:20	v		v		v		v		v		
30	10:25	v			v	v		v		v		
31	10:30	v		v		v		v		v		
32	10:35	v		v			v		v		v	
33	10:40	v		v			v		v		v	
34	10:45	v		v		v		v		v		
35	10:50	v		v		v		v		v		
36	10:55	v		v		v		v		v		

Tuesday, 21 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
37	11:00	v		v		v		v		v		Break time
38	11:05	v		v		v		v		v		
39	11:10		v	v		v		v		v		
40	11:15	v		v		v		v		v		
41	11:20	v		v		v		v		v		
42	11:25	v		v		v		v		v		
43	11:30	v		v		v		v		v		
44	11:35	v		v		v		v		v		
45	11:40	v		v		v		v		v		
46	11:45	v		v			v		v		v	
47	11:50	v		v			v		v		v	
48	11:55		v		v		v		v		v	
49	12:00		v		v		v		v		v	
50	12:05		v		v		v		v		v	
51	12:10		v		v		v		v		v	
52	12:15		v		v		v		v		v	
53	12:20		v		v		v		v		v	
54	12:25		v		v		v		v		v	
55	12:30		v		v		v		v		v	
56	12:35		v		v		v		v		v	
57	12:40		v		v		v		v		v	
58	12:45		v		v		v		v		v	
59	12:50		v		v		v		v		v	
60	12:55		v		v		v		v		v	
61	13:00		v		v		v		v		v	
62	13:05		v		v		v		v		v	Work Time
63	13:10	v		v			v		v		v	
64	13:15	v		v			v		v		v	
65	13:20	v		v			v		v		v	
66	13:25	v		v			v		v		v	
67	13:30	v		v			v		v		v	
68	13:35	v		v		v		v		v		
69	13:40	v		v		v		v		v		
70	13:45	v		v		v		v		v		
71	13:50	v		v		v		v		v		
72	13:55	v		v		v		v		v		
73	14:00	v		v		v		v		v		
74	14:05	v		v		v		v		v		

Tuesday, 21 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
75	14:10	v		v		v		v		v		
76	14:15	v		v		v		v		v		
77	14:20	v		v		v		v		v		
78	14:25		v		v	v		v		v		
79	14:30	v		v		v		v		v		
80	14:35	v		v		v		v		v		
81	14:40	v		v		v		v		v		
82	14:45	v		v		v		v		v		
83	14:50	v		v		v		v		v		
84	14:55	v		v		v		v		v		
85	15:00	v		v		v		v		v		
86	15:05	v		v		v		v		v		
87	15:10	v			v	v		v		v		
88	15:15	v		v		v		v		v		
89	15:20	v		v		v		v		v		
90	15:25	v		v		v		v		v		
91	15:30	v		v		v		v		v		
92	15:35	v		v		v		v		v		
93	15:40	v		v		v		v		v		
94	15:45	v		v		v		v		v		
95	15:50	v		v		v		v		v		
96	15:55		v	v		v		v		v		
Total		75	21	76	20	67	29	67	29	67	29	
Total Time Productive		352										
Total Time Idle		128										
Volume Produced (kg)		88,51										

Appendix 9 Observation Data Labour Productivity in the Field for Day 9

Wednesday, 22 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
1	08:00		v		v		v	v		v		Work Time
2	08:05		v	v			v	v		v		
3	08:10	v		v			v	v		v		
4	08:15	v		v		v		v		v		
5	08:20	v			v	v		v		v		
6	08:25	v			v	v		v		v		
7	08:30	v		v		v		v		v		
8	08:35	v		v		v		v		v		
9	08:40	v		v		v			v		v	
10	08:45	v		v		v		v		v		
11	08:50	v		v		v		v		v		
12	08:55	v		v		v		v		v		
13	09:00	v		v		v		v		v		
14	09:05	v		v		v		v		v		
15	09:10	v		v		v		v		v		
16	09:15	v		v		v		v		v		
17	09:20	v		v		v		v		v		
18	09:25	v		v		v		v		v		
19	09:30	v		v		v		v		v		
20	09:35	v		v		v		v		v		
21	09:40	v		v		v		v		v		
22	09:45	v		v		v		v		v		
23	09:50	v		v		v		v		v		
24	09:55	v		v		v		v		v		
25	10:00	v		v		v		v		v		
26	10:05	v		v		v		v		v		
27	10:10	v		v		v		v		v		
28	10:15	v		v			v	v		v		
29	10:20	v		v			v	v		v		
30	10:25	v		v		v		v		v		
31	10:30	v		v		v		v		v		
32	10:35		v	v		v			v		v	
33	10:40		v	v		v			v		v	
34	10:45	v		v		v		v		v		
35	10:50	v			v	v		v		v		
36	10:55	v			v	v		v		v		

Wednesday, 22 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
37	11:00	v			v	v		v		v		
38	11:05	v		v		v		v		v		
39	11:10	v		v		v		v		v		
40	11:15	v		v		v		v		v		
41	11:20	v		v		v		v		v		
42	11:25	v		v		v		v		v		
43	11:30	v		v		v		v		v		
44	11:35	v		v		v		v		v		
45	11:40	v		v		v		v		v		
46	11:45	v		v		v			v		v	
47	11:50	v			v		v		v		v	
48	11:55	v			v		v		v		v	
49	12:00		v		v	v			v		v	
50	12:05		v		v		v		v		v	
51	12:10		v		v		v		v		v	
52	12:15		v		v		v		v		v	
53	12:20		v		v		v		v		v	
54	12:25		v		v		v		v		v	
55	12:30		v		v		v		v		v	
56	12:35		v		v		v		v		v	
57	12:40		v		v		v		v		v	
58	12:45		v		v		v		v		v	
59	12:50		v		v		v		v		v	
60	12:55		v		v		v		v		v	
61	13:00		v	v			v		v		v	
62	13:05		v	v			v		v		v	
63	13:10		v	v			v		v		v	
64	13:15	v		v		v			v		v	
65	13:20	v		v		v			v		v	
66	13:25	v		v		v			v		v	
67	13:30	v		v		v			v		v	
68	13:35	v		v		v		v		v		
69	13:40	v		v		v		v		v		
70	13:45	v		v		v		v		v		
71	13:50	v		v		v		v		v		
72	13:55	v		v		v		v		v		
73	14:00	v		v		v		v		v		
74	14:05	v		v		v		v		v		

Wednesday, 22 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
75	14:10	v		v		v		v		v		
76	14:15	v		v		v		v		v		
77	14:20	v		v		v		v		v		
78	14:25	v		v		v		v		v		
79	14:30	v		v		v		v		v		
80	14:35		v		v	v		v		v		
81	14:40		v		v	v		v		v		
82	14:45	v		v		v		v		v		
83	14:50	v		v		v		v		v		
84	14:55	v		v		v		v		v		
85	15:00	v		v		v		v		v		
86	15:05	v		v		v		v		v		
87	15:10	v		v		v		v		v		
88	15:15	v		v		v		v		v		
89	15:20	v		v		v		v		v		
90	15:25	v		v		v		v		v		
91	15:30	v		v		v		v		v		
92	15:35	v		v		v		v		v		
93	15:40	v		v		v		v		v		
94	15:45	v		v		v		v		v		
95	15:50	v		v		v		v		v		
96	15:55	v		v		v		v		v		
Total		75	21	74	22	75	21	71	25	71	25	
Total Time Productive		366										
Total Time Idle		114										
Volume Produced (kg)		91,28										

Appendix 10 Observation Data Labour Productivity in the Field for Day 10

Thursday, 23 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
1	08:00		v	v		v		v		v		Work Time
2	08:05	v		v		v		v		v		
3	08:10	v		v		v		v		v		
4	08:15	v		v		v		v		v		
5	08:20	v		v		v		v		v		
6	08:25	v		v		v		v		v		
7	08:30	v		v		v		v		v		
8	08:35	v		v		v		v		v		
9	08:40	v		v		v		v		v		
10	08:45	v		v		v		v		v		
11	08:50	v		v		v		v		v		
12	08:55	v		v		v		v		v		
13	09:00	v		v		v		v		v		
14	09:05	v		v		v		v		v		
15	09:10	v		v		v		v		v		
16	09:15	v		v		v		v		v		
17	09:20	v		v		v		v		v		
18	09:25	v		v		v		v		v		
19	09:30	v		v		v		v		v		
20	09:35	v		v		v		v		v		
21	09:40	v		v		v		v		v		
22	09:45	v		v		v		v		v		
23	09:50	v			v	v		v		v		
24	09:55		v		v	v		v		v		
25	10:00		v	v		v		v		v		
26	10:05		v	v		v		v		v		
27	10:10	v		v		v		v		v		
28	10:15	v		v		v		v		v		
29	10:20	v		v		v		v		v		
30	10:25	v		v		v		v		v		
31	10:30	v		v		v		v		v		
32	10:35	v		v		v		v		v		
33	10:40	v		v		v		v		v		
34	10:45	v		v		v		v		v		
35	10:50	v		v		v		v		v		
36	10:55	v		v		v		v		v		

Thursday, 23 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
37	11:00	v		v		v		v		v		
38	11:05	v		v		v		v		v		
39	11:10	v		v		v		v		v		
40	11:15	v		v		v		v		v		
41	11:20	v		v		v		v		v		
42	11:25	v		v		v		v		v		
43	11:30	v		v		v		v		v		
44	11:35	v		v		v		v		v		
45	11:40	v		v		v		v		v		
46	11:45	v		v		v		v		v		
47	11:50	v			v	v		v		v		
48	11:55		v		v	v		v		v		
49	12:00		v		v	v		v		v		
50	12:05		v		v		v		v		v	
51	12:10		v		v		v		v		v	
52	12:15		v		v		v		v		v	
53	12:20		v		v		v		v		v	
54	12:25		v		v		v		v		v	
55	12:30		v		v		v		v		v	
56	12:35		v		v		v		v		v	
57	12:40		v		v		v		v		v	
58	12:45		v		v		v		v		v	
59	12:50		v		v		v		v		v	
60	12:55	v			v		v		v		v	
61	13:00	v		v			v		v		v	
62	13:05	v		v			v		v		v	
63	13:10	v		v			v		v		v	
64	13:15	v		v		v		v		v		
65	13:20	v		v		v		v		v		
66	13:25	v		v		v		v		v		
67	13:30	v		v		v		v		v		
68	13:35	v		v		v		v		v		
69	13:40	v		v		v		v		v		
70	13:45	v		v		v		v		v		
71	13:50	v		v		v		v		v		
72	13:55	v		v		v		v		v		
73	14:00	v		v		v		v		v		

Thursday, 23 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
74	14:05	v		v		v		v		v		
75	14:10	v		v		v		v		v		
76	14:15	v		v		v		v		v		
77	14:20	v		v		v		v		v		
78	14:25	v		v		v		v		v		
79	14:30	v		v		v		v		v		
80	14:35	v			v	v		v		v		
81	14:40	v			v	v		v		v		
82	14:45	v		v		v		v		v		
83	14:50	v		v		v		v		v		
84	14:55	v		v		v		v		v		
85	15:00		v	v		v		v		v		
86	15:05		v	v		v		v		v		
87	15:10	v		v		v		v		v		
88	15:15	v		v		v		v		v		
89	15:20	v		v		v		v		v		
90	15:25	v		v		v		v		v		
91	15:30	v		v		v		v		v		
92	15:35	v		v		v		v		v		
93	15:40	v		v		v		v		v		
94	15:45	v		v		v		v		v		
95	15:50	v		v		v		v		v		
96	15:55	v		v		v		v		v		
Total		78	18	78	18	82	14	82	14	82	14	
Total Time Productive		402										
Total Time Idle		78										
Volume Produced (kg)		80,93										

Appendix 11 Observation Data Labour Productivity in the Field for Day 11

Friday, 24 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
1	08:00		v		v		v		v		v	Work Time
2	08:05		v		v	v		v		v		
3	08:10	v		v		v		v		v		
4	08:15	v		v		v		v		v		
5	08:20	v		v			v		v		v	
6	08:25		v		v		v		v		v	
7	08:30	v		v		v		v		v		
8	08:35	v		v		v		v		v		
9	08:40	v		v		v		v		v		
10	08:45	v		v		v		v		v		
11	08:50	v		v		v		v		v		
12	08:55	v		v		v		v		v		
13	09:00	v		v		v		v		v		
14	09:05	v		v		v		v		v		
15	09:10	v		v		v		v		v		
16	09:15	v		v		v		v		v		
17	09:20	v		v		v		v		v		
18	09:25	v		v		v		v		v		
19	09:30	v		v		v		v		v		
20	09:35	v		v		v		v		v		
21	09:40	v		v		v		v		v		
22	09:45	v		v		v		v		v		
23	09:50	v		v		v		v		v		
24	09:55	v		v		v		v		v		
25	10:00	v		v		v		v		v		
26	10:05	v		v		v		v		v		
27	10:10	v		v		v		v		v		
28	10:15	v		v		v		v		v		
29	10:20	v		v		v		v		v		
30	10:25	v		v		v		v		v		
31	10:30	v		v		v		v		v		
32	10:35	v		v		v		v		v		
33	10:40	v		v		v		v		v		
34	10:45	v		v		v		v		v		
35	10:50	v		v		v		v		v		
36	10:55	v		v		v		v		v		

Friday, 24 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
37	11:00	v		v		v		v		v		
38	11:05	v		v		v		v		v		
39	11:10	v		v		v		v		v		
40	11:15	v		v		v		v		v		
41	11:20	v		v		v		v		v		
42	11:25	v		v		v		v		v		
43	11:30		v	v		v		v		v		
44	11:35		v	v		v		v		v		
45	11:40		v	v		v		v		v		
46	11:45		v	v		v		v		v		
47	11:50		v	v		v		v		v		
48	11:55		v	v		v		v		v		
49	12:00		v		v	v		v		v		
50	12:05		v		v	v		v		v		
51	12:10		v		v	v		v		v		
52	12:15		v		v	v		v		v		
53	12:20		v		v		v		v		v	
54	12:25		v		v		v		v		v	
55	12:30		v		v		v		v		v	
56	12:35		v		v		v		v		v	
57	12:40		v		v		v		v		v	
58	12:45		v		v		v		v		v	
59	12:50		v		v		v		v		v	
60	12:55	v			v		v		v		v	
61	13:00	v			v		v		v		v	
62	13:05	v			v		v		v		v	
63	13:10	v			v	v		v		v		
64	13:15	v			v	v		v		v		
65	13:20	v		v		v		v		v		
66	13:25	v		v		v		v		v		
67	13:30	v		v		v		v		v		
68	13:35	v		v		v		v		v		
69	13:40	v		v		v		v		v		
70	13:45	v		v		v		v		v		
71	13:50	v		v		v		v		v		
72	13:55	v		v		v		v		v		
73	14:00	v		v		v		v		v		

Friday, 24 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I	P	I	
74	14:05	v		v		v		v		v		
75	14:10	v		v		v		v		v		
76	14:15	v		v		v		v		v		
77	14:20	v		v		v		v		v		
78	14:25	v		v		v		v		v		
79	14:30	v		v		v		v		v		
80	14:35	v		v		v		v		v		
81	14:40	v		v		v		v		v		
82	14:45	v		v		v		v		v		
83	14:50	v			v	v		v		v		
84	14:55	v			v	v		v		v		
85	15:00	v			v	v		v		v		
86	15:05	v			v	v		v		v		
87	15:10	v		v		v		v		v		
88	15:15	v		v		v		v		v		
89	15:20	v		v		v		v		v		
90	15:25	v		v		v		v		v		
91	15:30	v		v		v		v		v		
92	15:35	v		v		v		v		v		
93	15:40	v		v		v		v		v		
94	15:45	v		v		v		v		v		
95	15:50	v		v		v		v		v		
96	15:55	v		v		v		v		v		
Total		76	20	73	23	83	13	83	13	83	13	
Total Time Productive		398										
Total Time Idle		82										
Volume Produced (kg)		86,10										

Appendix 12 Observation Data Labour Productivity in the Field for Day 12

Saturday, 25 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I		v	
1	08:00	v		v		v		v		v		Work Time
2	08:05	v		v		v		v		v		
3	08:10	v		v		v		v		v		
4	08:15	v		v		v		v		v		
5	08:20	v		v		v		v		v		
6	08:25	v		v		v		v		v		
7	08:30	v		v		v		v		v		
8	08:35	v		v		v		v		v		
9	08:40	v		v		v		v		v		
10	08:45	v		v		v		v		v		
11	08:50	v		v			v		v		v	
12	08:55	v		v			v		v		v	
13	09:00	v		v		v		v		v		
14	09:05	v		v		v		v		v		
15	09:10	v		v		v		v		v		
16	09:15	v		v		v		v		v		
17	09:20	v		v		v		v		v		
18	09:25	v		v		v		v		v		
19	09:30	v		v		v		v		v		
20	09:35	v		v		v		v		v		
21	09:40	v		v		v		v		v		
22	09:45	v		v		v		v		v		
23	09:50	v		v		v		v		v		
24	09:55	v		v		v		v		v		
25	10:00	v		v		v		v		v		
26	10:05	v		v		v		v		v		
27	10:10	v		v		v		v		v		
28	10:15	v		v		v		v		v		
29	10:20	v		v		v		v		v		
30	10:25	v		v		v		v		v		
31	10:30	v		v		v		v		v		
32	10:35	v		v		v		v		v		
33	10:40	v		v		v		v		v		
34	10:45	v		v		v		v		v		
35	10:50	v		v		v		v		v		
36	10:55	v		v		v		v		v		

Saturday, 25 March 2023

No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I		v	
37	11:00	v		v		v		v		v		
38	11:05	v		v		v		v		v		
39	11:10	v		v		v		v		v		
40	11:15	v		v		v		v		v		
41	11:20	v		v		v		v		v		
42	11:25	v		v		v		v		v		
43	11:30	v		v		v		v		v		
44	11:35	v		v		v		v		v		
45	11:40	v		v		v		v		v		
46	11:45	v		v		v		v		v		
47	11:50	v			v	v		v		v		
48	11:55		v		v	v		v		v		
49	12:00		v		v	v		v		v		
50	12:05		v		v		v		v		v	
51	12:10		v		v		v		v		v	
52	12:15		v		v		v		v		v	
53	12:20		v		v		v		v		v	
54	12:25		v		v		v		v		v	
55	12:30		v		v		v		v		v	
56	12:35		v		v		v		v		v	
57	12:40		v		v		v		v		v	
58	12:45		v		v		v		v		v	
59	12:50		v		v		v		v		v	
60	12:55	v			v		v		v		v	
61	13:00	v		v			v		v		v	
62	13:05	v		v			v		v		v	
63	13:10	v		v			v		v		v	
64	13:15	v		v		v		v		v		
65	13:20	v		v		v		v		v		
66	13:25	v		v		v		v		v		
67	13:30	v		v		v		v		v		
68	13:35	v		v		v		v		v		
69	13:40	v		v		v		v		v		
70	13:45	v		v		v		v		v		
71	13:50	v		v		v		v		v		
72	13:55	v		v		v		v		v		
73	14:00	v		v		v		v		v		

Saturday, 25 March 2023

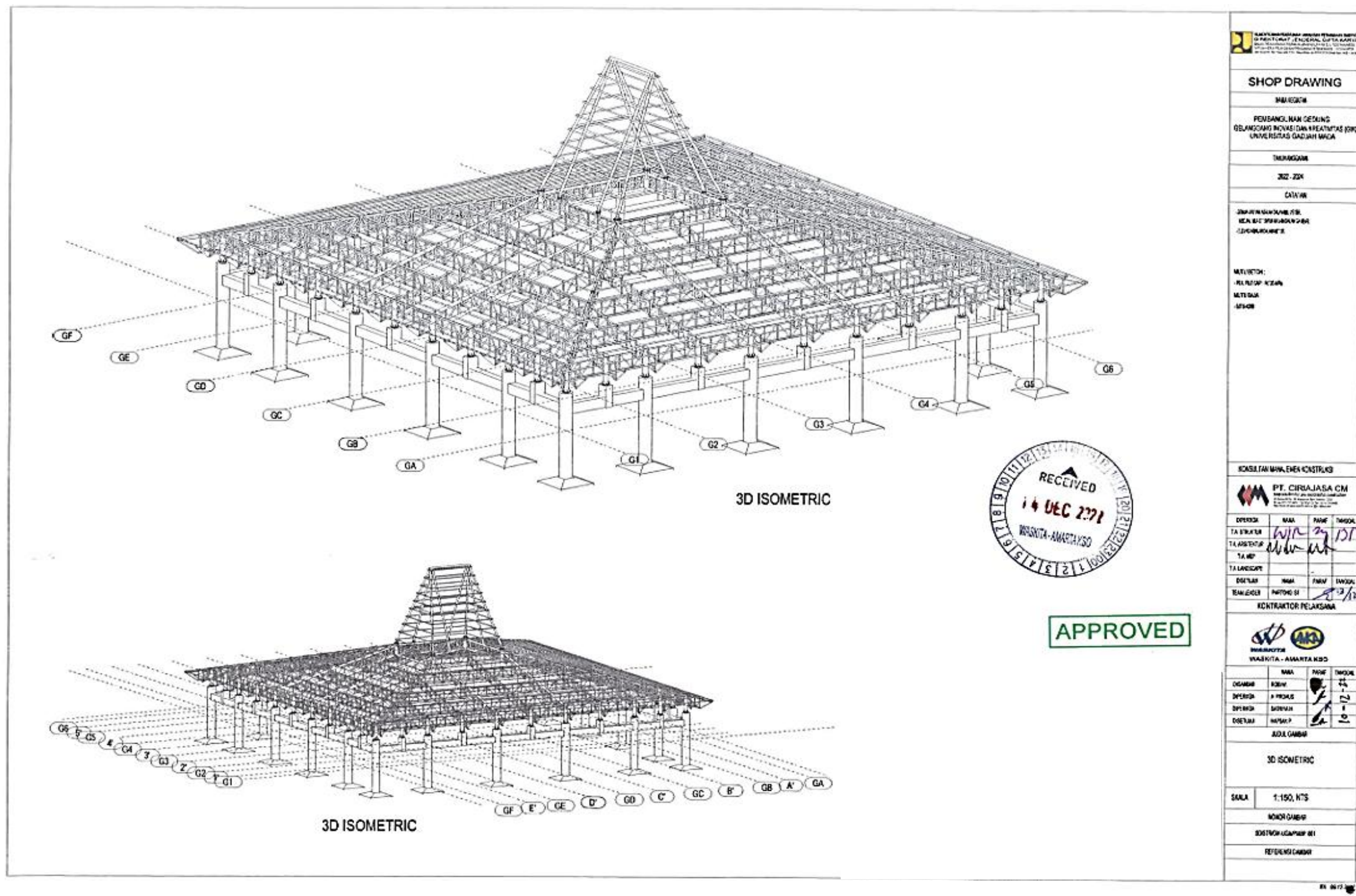
No	Time	Labours										Notes
		welder				Helper						
		Welder 1		Welder 2		Helper 1		Helper 2		Helper 3		
		P	I	P	I	P	I	P	I		v	
74	14:05	v		v		v		v		v		
75	14:10	v		v		v		v		v		
76	14:15	v		v		v		v		v		
77	14:20	v		v		v		v		v		
78	14:25	v		v		v		v		v		
79	14:30	v		v		v		v		v		
80	14:35	v			v	v		v		v		
81	14:40	v			v	v		v		v		
82	14:45	v		v		v		v		v		
83	14:50	v		v		v		v		v		
84	14:55	v		v		v		v		v		
85	15:00		v	v		v		v		v		
86	15:05		v	v		v		v		v		
87	15:10	v		v		v		v		v		
88	15:15	v		v		v		v		v		
89	15:20	v		v		v		v		v		
90	15:25	v		v		v		v		v		
91	15:30	v		v		v		v		v		
92	15:35	v		v		v		v		v		
93	15:40	v		v		v		v		v		
94	15:45	v		v			v		v		v	
95	15:50	v		v			v		v		v	
96	15:55	v		v			v		v		v	
Total		82	14	80	16	77	19	77	19	77	19	
Total Time Productive		393										
Total Time Idle		87										
Volume Produced (kg)		75,57										

Appendix 13 Documentation Data Processing

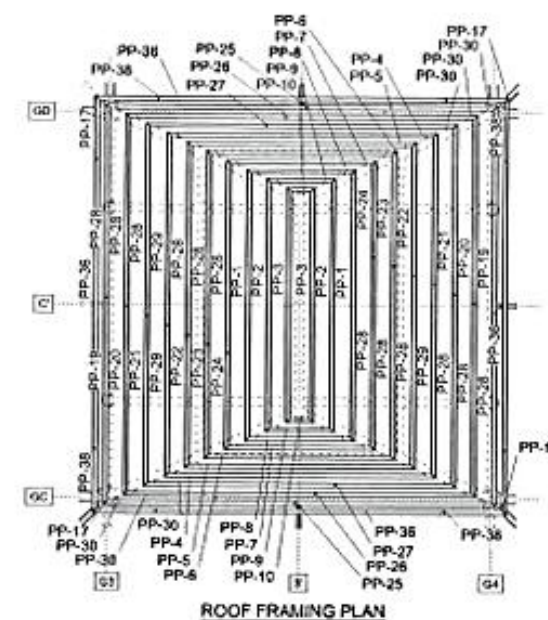
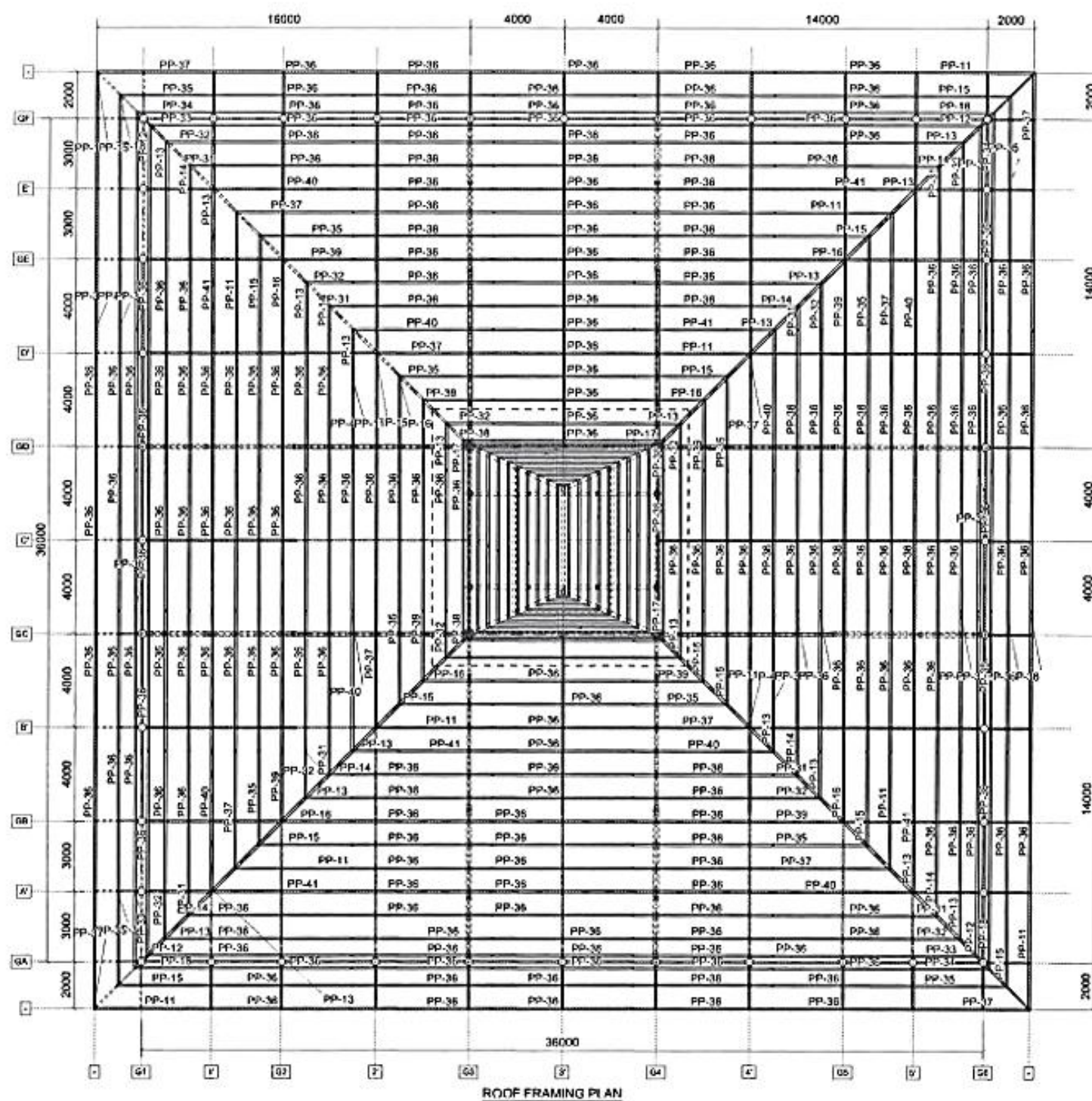




Appendix 14 Technical Drawing of Joglo Roof



Appendix 16 Technical Drawing of Joglo Roof



APPROVED

[illegible]