



Optimizing Project Performance by Applying the Crashing Method to Road Construction Project

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Abstract. In the implementation of projects, various obstacles are often encountered which cause delays which have an impact not only on the duration of implementation but also on the costs incurred. These constraints can be in the form of a lack of resources, weather factors to social factors. Thus, it is necessary to accelerate and optimize what can be done to overcome the delay. As well as efficient resource management. One of the acceleration methods that can be used is the Crashing method. One of them is the application of the crashing method to the Ringinrejo - BTS road construction project. Regency. Malang STA 2+350 – 6+300 which experienced delays in its implementation. After analyzing the remaining work, the duration of the remaining work was 273 days or completed on December 31, 2022. In the initial planning, the project was scheduled for completion on October 3, 2022, so based on this, the project experienced a delay of 89 days. The total minimum fee that must be incurred is IDR 1,524,960.00 with an additional fee of IDR 21,180,000.00 per day. Daily productivity for ordinary excavation works, which was originally 303.20 m³/hour, increased to 909.59 m³/hour. For daily productivity on ordinary embankment work which was originally 371.92 m³/hour to 743.84 m³/hour and productivity on road construction work which was originally 330.91 m³/hour to 661.81 m³/hour. After the acceleration using the crashing analyzing method on existing critical paths, it is known that the duration of project implementation which was originally 273 days became 184 days by adding the number of heavy equipment. with an additional fee of IDR 1,524,960,000.

Keywords: Project Delay, Crashing Method, ASSET, Project Management

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1. Introduction

Research for this final project is located at the Ringinrejo Road Development Project - Bts.Kab. Malang is located in Ringinrejo Village, Wates District, Blitar Regency, East Java. In this study used



quantitative methods. This method has been used for a long time, so it is often called the traditional method. This type of research, starting from the beginning to making the research design, is carried out in a systematic, planned and structured manner. Project management refers to how resources are available to managers so that they can be properly applied to a construction project. The resources used in development projects include labour, equipment, materials, methods and money[1]. The process of setting goals and objectives that require the preparation of resources to achieve them is known as planning activities[1].

There are three factors to consider when planning activities. These three factors are known as the three constraints (triple constraint). To make the best scheduling decisions, the use of resources during implementation requires effective and efficient planning. The definition of scheduling is determining the time and sequence of work in project implementation to produce the overall time duration[2].

Project management is an important component for the sustainability of a project. One of them is the road construction project which is an infrastructure project that has been developed by the government. This is because roads play an important role in increasing the economic and social activities of the people in the region. Likewise in the implementation of the Ringinrejo - BTS road construction project. regency. Malang STA 2+350 – 6+300. With the various obstacles that occurred including weather factors to social factors, the project experienced delays so that efforts were needed to accelerate to catch up with the delay so that it was in accordance with the planned schedule. So the purpose of this research is to find out the amount of time needed to complete the project after adding the number of heavy equipment used.

1.1. Problem Formulation

1. What is the total duration of the project after the acceleration analysis is carried out using the crashing method?
2. What is the minimum cost that must be incurred after the acceleration analysis is carried out using the crashing method?
3. What are the results of increasing the performance productivity of the heavy equipment used?

1.2. Project Management

The definition of management basically includes methods, techniques, or procedures to achieve certain goals in a systematic and effective manner through planning, organizing, actuating, and controlling tasks by utilizing existing resources effectively. effective[1]. Project management consists of three stages, namely:

1. Planning

Planning is identifying many options for action and choosing the best one.

2. Scheduling

Scheduling is determining the time and sequence of work in project implementation to produce the overall time duration (Mubarak, 2010).

3. Controlling

Control is the process of ensuring what has been achieved, assessing performance, and if necessary taking corrective action (Erviyanto I, 2005).

1.3. Scheduling Method

Scheduling methods used in a project include:

1. Bars (gant)Charts

- 2. Curve – S
- 3. Network Planning Diagrams:
 - a. Activities on Arrow
 - b. Activity on Node
 - c. Critical Path Method(CPM)

1.4. Activity on Node

Activity on Node(AON) has a representation that is closely related to what is called the Precedence Diagram Method (PDM)[5]. In this method there are several time relationships, namely:

1. Early Start(ES) =The earliest time an activity can start after the previous activity has finished.
2. Late Start(LS) =The latest time an activity can be completed without slowing down the completion of the project schedule.
3. Early Finish(EF) =The earliest time an activity can be completed if it starts at the earliest time and is completed according to the duration.
4. Late Finish(LF) =The latest time an activity can be started without causing delays in project completion.

ES	JENIS KEGIATAN	EF
LS		LF
NO.KEG.		DURASI
DURASI		FLOAT
ES	NO.KEG.	EF
JENIS KEGIATAN		

Figure 1. Activity Type in Activity on Node

1.5. Project Duration Acceleration

Project acceleration means shortening the normal duration of project work (or it can also be called schedule compression).[2]. The basic function of project management is to manage matters relating to the three constraints (triple constraint)[6]. The idea is that projects are generally limited to selecting two of the three elements and sacrificing the others to get the two selected[7]. So that it can be said in terms of the triple constraint, one of them is good – fast, good – cheap, or fast – cheap, but you cannot choose all three.

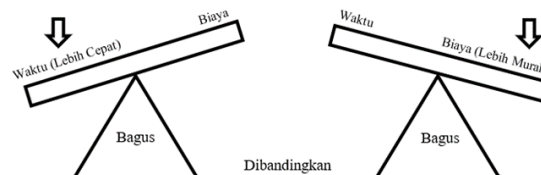


Figure 2. Acceleration On Project

1.6. Critical Path

The critical path is the work path where the execution time of the activity cannot be delayed[8]. The critical path is the path that most determines the overall project completion time[9]. Accelerating every activity, especially those that are on a crucial trajectory and with the lowest acceleration costs, are things that need to be taken into account in accelerating project completion[8].

2. Methods

The data used is secondary data. Where at this stage the data - the data needed is RAB, HSPK, S – Curve, daily reports and supporting data. In this study there are several stages of data analysis, namely Identification of Activities on the Critical Path, Determining Crashing Scenarios, Determining Crash Duration and Crash Costs, Calculating Cost Slope, Reviewing Time Cost Trade Off (TCTO) Analysis Results, Identifying Heavy Equipment Productivity, and Calculating Increased Productivity of Heavy Equipment.

2.1. Crash Method

Examining all project operations with a focus on activities that are on the critical path is known as “crashing”, and is a deliberate, methodical, and analytical procedure. The shortest time required to complete an activity that is technically still achievable, assuming resources are not an obstacle[10]. To speed up the process, there are four variables that can be improved: the number of workers, overtime scheduling, use of heavy equipment, and construction techniques in the field[11]. To further analyze the relationship between time and cost of an activity, the following definition is used[4]:

- a. The normal timeframe is the amount of time required to complete the job efficiently, without neglecting overtime and other additional efforts such as renting more complex equipment
- b. Normal costs are the direct costs required to complete an activity in an ordinary amount of time.
- c. Shortened Time Frame (crash time) accelerated time required to perform a technically feasible task. Resources are not seen as a limitation in this situation.
- d. Cost for Shortened Time (crash cost) is the total direct expenditure to complete the job in the smallest amount of time known as the crash cost.
- e. The cost for the duration of the acceleration each day (cost slope) is the increase in costs for each reduction in the duration of the project. By accelerating the duration of work on certain activities, there will be additional costs due to the acceleration of the duration carried out.

Or the relationship between time and cost can be seen in the following figure:

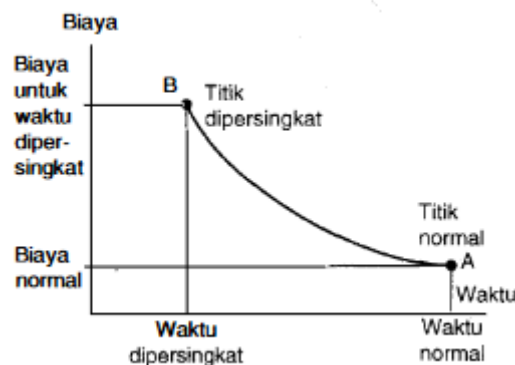


Figure 3. Relationship between time and cost in normal and accelerated circumstances

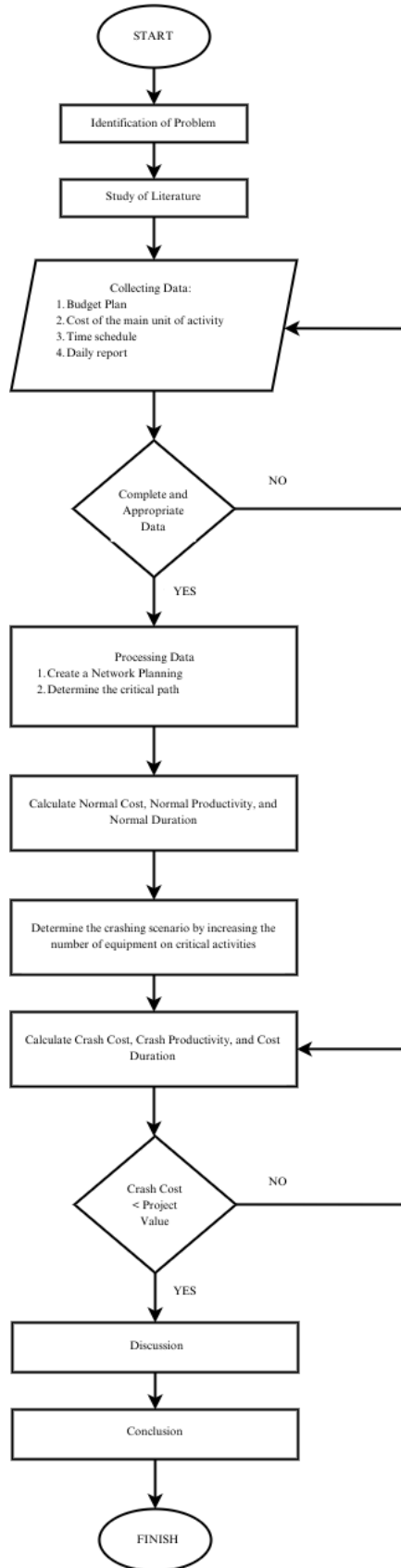


Figure 4. Research Methodology

3. Results and Discussion

For the work on this Final Project general data was obtained from PT. Ridlatama Bahtera Construction. PT. Ridlatama Bahtera Construction as a contractor on the Ringinrejo – Bts Road Construction project. Regency. Malang STA 2+350 – 6+300. The data to be processed is as follows:

3.1. Project General Data

Ringinrejo – BTS road construction project. Regency. Malang STA 2+350 – 6+300 starts on 10 May 2021 with a duration of 670 days. In this study, activities that were accelerated were only activities that were on the critical path at week 47 to completion.

The following is the Road Construction Project data,

- Project name : Ringinrejo Road Development Project – BTS. Malang Regency STA 2+350 – 6+300
- Execution time : 670 days
- Contract value : IDR 46,004,000,000,-

3.2. Critical

After knowing the duration of each work on the project at the scheduling stage, or you can also refer to the project plan schedule. After the duration of each job is known, then determine the relationship of each work which will then be included in the 2016 Microsoft Project. Thus, it will be known that several work activities are on the critical path. Where in the 2016 Microsoft Project for bar charts or network diagrams of work that are included in the critical path will be red as shown in Figure 3. It is the work that is on this critical path that will be accelerated (crashing).

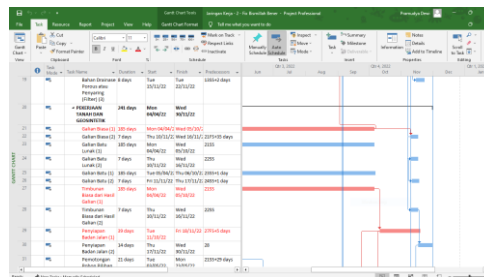


Figure 5. Critical Path Determination

Table 1. Work on Critical Path

No.	Work on the Critical Path	Volume	units	Normal Duration (Days)
1.	Common Digs (1)	109,446.96	m3	110
2.	Ordinary Stockpiles from Excavations	15,241.58	m3	112
3.	Road Agency Preparation (1)	47,400.00	m3	54

3.3. Calculating Normal Cost

Normal costs (normal costs) in the project consist of direct costs (direct costs) and indirect costs (indirect costs). Direct costs are obtained from the multiplication of the residual volume and the unit price of each job.

$$\text{Normal Cost} = \text{Work Volume} \times \text{Material Unit Price (1)}$$



Table 2. Normal Cost of Work Activity

No.	Work	Volume	units	Normal Fee (Rp)
1.	Common Digs (1)	109,446.96	m3	1,094,469,620.00
2.	Ordinary Stockpiles from Excavations	15,241.58	m3	303,612,353.28
3.	Road Agency Preparation (1)	47,400.00	m3	85,320,000.00

In this study, the total value of normal cost was IDR. 43,325,708,137 with direct costs of IDR. 40,755,208,137 and indirect costs of IDR. 2,570,500,000. This indirect cost includes housing, water needs, electricity needs and workers' wages.

3.4. Calculating Heavy Equipment

Machine productivity per hour is needed to find out the amount of machine productivity needed for each job. Machine productivity is calculated using the formula;

$$\text{Productivity} = (2) \frac{\text{Volume Pekerjaan}}{\text{Durasi Pekerjaan}}$$

For productivity on each job on the critical path will be described in the table

Table 3. Actual and Planned Productivity

No.	Work	Daily Productivity	Plan Productivity	Unit
1.	Common Dig (1)	303,20	994.97	m3/hour
2.	Ordinary Stockpiles from Excavations	371.92	136.09	m3/hour
3.	Road Agency Preparation (1)	330.91	574,27	m3/hour

3.5. Crash Method

In this study, the acceleration process (crashing) will be applied by increasing the number of heavy equipment. Then, some of these scenarios are compared in terms of costs in order to get the optimal acceleration scenario. The acceleration scenario is as follows,

1. Acceleration Scenario 1

This scenario is carried out by crashing the usual excavation work, namely,

No.	Pekerjaan Lintasan Kritis	Jenis Alat Berat	Jumlah	
			Normal	Crashing
1	Galian Biasa	Excavator	2	6
		Dump Truck	8	15
2	Timbunan Biasa dari Hasil Galian	Excavator	1	1
		Dump Truck	2	2
		Motor Grader	1	1
		Vibrator Roller	1	1
		Water Tank Truck	1	1
3	Penyiapan Badan Jalan	Motor Grader	1	1
		Vibrator Roller	1	1
4	Lapis Pondasi Agregat Kelas A			

Figure 6. Acceleration Scenario 1



2. Acceleration Scenario 2

This scenario is carried out by crashing the usual excavation works and ordinary embankments from the excavation, namely,

No.	Pekerjaan Lintasan Kritis	Jenis Alat Berat	Jumlah	
			Normal	Crashing
1	Galian Biasa	Excavator	2	6
		Dump Truck	8	15
2	Timbunan Biasa dari Hasil Galian	Excavator	1	2
		Dump Truck	2	6
		Motor Grader	1	1
		Vibrator Roller	1	1
		Water Tank Truck	1	1
3	Penyiapan Badan Jalan			

Figure 7. Acceleration Scenario 2

3. Acceleration Scenario 3

This scenario is carried out by crashing the usual excavation work and preparing the road body, namely,

No.	Pekerjaan Lintasan Kritis	Jenis Alat Berat	Jumlah	
			Normal	Crashing
1	Galian Biasa	Excavator	2	6
		Dump Truck	8	15
2	Timbunan Biasa dari Hasil Galian	Excavator	1	2
		Dump Truck	2	6
		Motor Grader	1	1
		Vibrator Roller	1	1
		Water Tank Truck	1	1
3	Penyiapan Badan Jalan	Motor Grader	1	2
		Vibrator Roller	1	1
4	Lapis Pondasi Agregat Kelas A			

Figure 8. Acceleration Scenario 3

4. Acceleration Scenario 4

This scenario is carried out by crashing on ordinary excavation work, ordinary piles of excavation results and preparation of road bodies, namely,

No.	Pekerjaan Lintasan Kritis	Jenis Alat Berat	Jumlah	
			Normal	Crashing
1	Galian Biasa	Excavator	2	6
		Dump Truck	8	15
2	Timbunan Biasa dari Hasil Galian	Excavator	1	2
		Dump Truck	2	6
		Motor Grader	1	1
		Vibrator Roller	1	1
		Water Tank Truck	1	1
3	Penyiapan Badan Jalan	Motor Grader	1	2
		Vibrator Roller	1	1
4	Lapis Pondasi Agregat Kelas A			

Figure 9. Acceleration Scenario 4

Then calculate crashing productivity for each of the above scenarios by adding the number of heavy equipment to obtain the following calculation,



Table 4. Crashing Productivity

No.	Description	Daily Productivity	Crashing Productivity	Unit
1.	Crash Scenario 1	303,20	909.59	m3/hour
2.	Crash Scenario 2	675,12	1350.24	m3/hour
3.	Crash Scenario 3	634,10	1571,40	m3/hour
4.	Crash Scenario 4	1006.02	2315,24	m3/hour

After obtaining acceleration scenarios, crashing duration calculations are performed for each acceleration scenario using the formula;

$$\text{Crashing duration} = (3) \frac{\text{Volume Pekerjaan}}{\text{Produktivitas Crashing}}$$

Table 5. Normal Duration and Crashin Duration

No.	Description	Normal Duration (Days)	Crashing Duration (Days)
1.	Crash Scenario 1	192	72
2.	Crash Scenario 2	304	164
3.	Crash Scenario 3	245	80
4.	Crash Scenario 4	357	171

After calculating the productivity and duration of crashing. The next step is to calculate the acceleration costs for each acceleration scenario, which is calculated by,

$$\text{Crash costs} = \text{Durationcrashing} \times \text{Total price of crashes (4)}$$

$$\text{Total cost of crashes} = \text{Costcrashing} + \text{normal fees (5)}$$

$$\text{Cost Slopes} = \frac{\text{Biaya crashing} - \text{biaya normal}}{\text{Durasi crashing}} (6)$$

Table 6. Normal Fee and Crashin Fee

No	Crash Scenarios	Normal Fee (Rp)	Crashing Cost (Rp)	Total Cost of Crashing (Rp)	Cost Slopes(/day)
1	Crash Scenario 1	IDR 1,094,469,620	IDR 1,524,960,000	IDR 2,619,429,620	IDR 21,180,000.00
2	Crash Scenario 2	IDR 1,398,081,973	IDR 1,885,600,000	IDR 3,283,681,973	IDR 25,100,000.00
3	Crash Scenario 3	IDR 1,179,789,620	IDR 1,588,774,865	IDR 2,917,699,350	IDR 29,280,000.00
4	Crash Scenario 4	IDR 1,483,401,973	IDR 1,949,414,865	IDR 3,432,816,838	IDR 33,200,000.00

From the calculation results above, it is found that the acceleration scenario 1 is the acceleration scenario with the lowest cost slope. For this reason, the acceleration scenario 1 will be used in the Time Cost – Trade Off analysis.

3.6. Analysis of Time Cost – Trade Off

After determining the scenario to be used, a time cost – trade off analysis is carried out on that scenario in order to obtain the optimum acceleration that can be carried out on the project. The acceleration scenario must not exceed the remaining value of the project contract that can be used to accelerate the amount of Rp. 2,678,291,863 for scenario 1, the percentage of the remaining loss is



Table 6. Normal Fee and Crashin Fee

No.	Crash Scenarios	Crashing Cost (Rp)	Remaining Cost after Crashing (Rp)	Percentage Loss of Residual Costs
1.	Crash scenario 1	IDR 1,524,960,000	IDR 58,862,243	85.50%

Thus, an alternative scenario of acceleration 1 can be used on this road project so that it can be completed on time and has the lowest cost slope. With a residual value that was originally IDR. 2,678,291,863 to IDR. 58,862,243. Or it can be explained in the following graph,

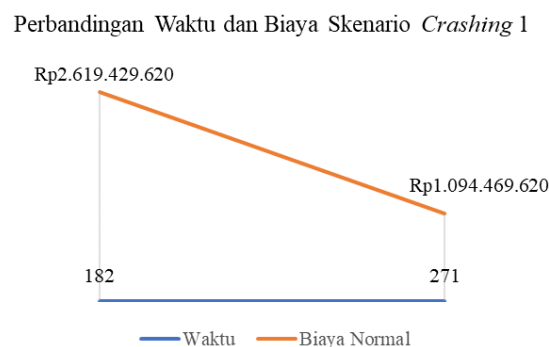


Figure 10. Comparison of Normal Time, Cost, Expedited Time and Cost

4. Conclusion

After processing the data, analyzing the data and discussing the results of this study, conclusions have been obtained to answer the research objectives. The description is as follows

1. After analyzing the remaining work, the duration of the remaining work was 273 days or completed on December 31, 2022. In the initial planning, the project was scheduled for completion on October 3, 2022, so based on this, the project experienced a delay of 89 days.
2. The total minimum fee that must be incurred is IDR 1,524,960.00 with an additional fee of IDR 21,180,000.00 per day
3. Daily productivity for ordinary excavation works, which was originally 303.20 m³/hour, increased to 909.59 m³/hour. For daily productivity on ordinary embankment work which was originally 371.92 m³/hour to 743.84 m³/hour and productivity on road construction work which was originally 330.91 m³/hour to 661.81 m³/hour.

In the case of this road project, the acceleration scenario that is more effective to carry out is the acceleration 1 scenario, namely by increasing productivity in ordinary excavation work. With normal work costs of IDR 1,094,469,620.00 and crashing costs of IDR 1,524,960.00 or an increase in costs of 1.40% of normal costs with remaining costs of IDR 58,862,243.00.

References

- [1] I. Widiyanti and Lenggogeni, *Construction Management*. PT. ROSDAKARYA TEENAGERS, 2013.
- [2] S. Mubarak, *Construction Project Scheduling and Control Second Edition*, 2nd ed. John



- Wiley & Sons, Inc., 2010. doi: 10.1007/978-3-642-41714-6_34378.
- [3] S. . Nunally, *Construction Methods and Management*, 7th ed. United States of America: Pearson Prentice Hall, 2007.
- [4] AA Maulana and MA Kalijaga, "Analysis of Project Acceleration Using the Crashing Method with Work Shift System on Projects," no. september, pp. 18–23, 2021.
- [5] DA Marco, *Project Management for Facility Construction*. Springer Heidelberg Dordrecht, 2011. doi: 10.1007/978-3-642-17092-8.
- [6] W. Ervianto I, *Construction Project Management Third Edition*, 3rd ed. 2005. [Online]. Available: http://katalog.kemdikbud.go.id/index.php?p=show_detail&id=91316
- [7] CJ Van Wyngaard, JHC Pretorius, and L. Pretorius, "Theory of the triple constraint -A conceptual review," *IEEE Int. Conf. eng. Eng. Eng. Manag.*, no. December 2019, pp. 1991–1997, 2012, doi: 10.1109/IEEM.2012.6838095.
- [8] H. Rani A, *Construction Project Management*, no. November 2016. 2016. [Online]. Available: https://www.researchgate.net/publication/316081639_Manajemen_Proyek_Konstruksi
- [9] AC Siregar and Iffiginia, "Using the Critical Path Method (CPM) for Evaluating the Time and Cost of Project Implementation," *Tech. J. Science and Technology.*, vol. 15, no. 2, p. 102, 2019, doi: 10.36055/tjst.v15i2.6816.
- [10] A. Ridwan, "Analysis of Project Acceleration Using the Crashing Method With the Addition of Four Hours Working Hours and Work Shift System (Case Study: Malang Hospital Building Project)," *J.App. Shipping and Ports*, vol. 11, no. 1, pp. 35–53, 2020, doi: 10.30649/japk.v11i1.61.
- [11] EH Manurung, "Analysis of Project Duration Acceleration with Minimal Cost Addition," *Seminar Proceedings. Nas. Science and Technology. 2018*, pp. 1–12, 2018, [Online]. Available: journal.umj.ac.id/index.php/semnastek
- [12] AACE International, "Skills & Knowledge of Cost Engineering". S. J. Amos. 2004
- [13] A.A. Alamsyah, "Rekayasa Lalu Lintas Edisi Revisi". In UPT Penerbitan Universitas Muhammadiyah Malan. 2008
- [14] H. Abrar. "Manfaat Penjadwalan In Manajemen Konstruksi". 2011, pp. 149-150, 2011.
- [15] Association for Project Managment. "Planning, Scheduling, Monitoring and Control". 2015
- [16] C. Chatfield and T. Johnson. "Microsoft Projejt 2016 Step by Step". In Microsoft Press, 1st ed, Vol. 5, Issue 3. 2016
- [17] M.P Institute. "Diagram Alir Perencanaan" In pedoman Kerangka Ilmu Manajemen Proyek. 2017. Isuue 1, p, 572, 2017.
- [18] D. Lock. "Project Management 8th ed.". Gower Edition. 2003
- [19] PP No. 34 Tahun 2006. 2006
- [20] A. Husen. "Proses Manajemen Proyek. Pdf". Manajemen Proyek. 2011. P. 5, 2011