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TIME ACCELERATION ANALYSIS USING THE TIME COST TRADE OFF METHOD ON THE WHEAT SILO AND PELLET SILO STRUCTURE REPAIR PROJECT PHASE III IN SURABAYA

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Abstract

The wheat silo and pellet silo structural repair project Phase III in Surabaya holds great significance for the wheat flour processing industry in Indonesia. PT Indofood Sukses Makmur Tbk Bogasari Surabaya Division, as one of the leading wheat flour producers, required structural repairs on both silos to ensure the smooth operation of the plant and the quality of the final product. Given the importance of time and cost in the success of this project, an effective approach to time and cost management was essential. The project necessitates proper project management to avoid delays and cost overruns, with a budget of IDR 28,011,000,000 and an estimated duration of 455 calendar days. This research employs the Time Cost Trade Off (TCTO) method to analyze options for accelerating project time by considering additional costs that may arise. Microsoft Project software is utilized to identify the critical path, allowing project managers to focus on activities with the greatest impact on the overall schedule. The results indicate that the critical path of the project includes activities such as mobilization and demobilization, administration and reporting, work safety, and repair of the old grain silo. By using TCTO, the project completion time can be accelerated to 359 days from 455 days, reducing the duration by 21.10%.

Keywords: *Acceleration, Wheat Silo, Pellet Silo, MS Project, Time Cost Trade Off*

1. INTRODUCTION

In Indonesia, infrastructure development and the expansion of the construction industry are on the rise. This expansion is largely driven by the rapid expansion of the domestic real estate market, private investment, and government spending on infrastructure projects. In order to improve the lives of its people, the need for development is increasing in all fields, especially in developing countries. There is much progress to be made; this lag must be followed up with development in all sectors. The development consists of the construction of physical projects, such as buildings, bridges, toll roads, large or small companies, and telecommunications networks (Abdilah et al., 2021).

Construction projects are a series of sensitive work mechanisms, because every aspect of the project affects one another. In project implementation, there are often schedule mismatches in the field which result in additional time and cost overruns. The causes of delays that often occur are due to design changes, weather factors, inadequate needs for workers, materials, or equipment, planner errors or specifications. The consequence of this acceleration in development completion is an increase in direct costs (Vebiola & Waskito, 2020).

PT Indofood Sukses Makmur Tbk. Bogasari Surabaya Division began operations on July 10, 1972, located on Jl. Nilam Timur No. 16 Tanjung Perak, Surabaya. Occupies an area of ± 14 Ha. With a milling capacity of 5,900 tons of wheat / day and a total flour production of 1.6 million tons per year. In the procurement and storage of raw materials in the form of wheat grain before being processed into flour, it needs to be stored in a place called silo, and the silo owned by Bogasari is a concrete silo. Silos owned by Bogasari are divided into 2 types, namely wheat silos for storing wheat and pellet silos for storing pellets, namely the remaining processed wheat skin that has been wasted which is usually used for animal feed mixture.

In Bogasari there are 4 complexes, namely the old pellet silo totaling 18 pieces with a height of 42 m, the new pellet silo totaling 24 pieces with a height of 40 m, the old wheat silo totaling 36 pieces with a height of 50 m, and the new wheat silo totaling 48 pieces with a height of 36.95m. Silo buildings are needed for the continuity of production, therefore maintenance of these buildings is carried out periodically every 20 years.

In the project work of repairing the structure of wheat silos and pellet silos Phase 3, 24 silos were carried out which absorbed a budget of Rp. 28,011,000,000 (Twenty Eight Billion Eleven Million Rupiah) which must be completed within an estimated time of 455 calendar days. During the work process of this silo repair project, bulk production loading and unloading activities continue to run, this results in increasingly complex and complicated construction projects, as well as weather factors when it rains which are always accompanied by strong winds due to the location around the waterfront, which often hinders work at heights using gondolas and access into silos which are only in the form of manholes complicating the installation of supporting equipment in the work, so proper project management is needed so that the project does not exceed the specified time limit.

The stage III wheat silo and pellet silo structure repair project in Surabaya faced significant challenges. Based on the project progress report and interviews with the project manager and field team, it was identified that several key activities were delayed. The excavation and foundation installation activities experienced constraints due to unstable soil conditions and bad weather, which caused work delays. In addition, the installation of the steel structure was delayed due to the late delivery of materials from the supplier. Concrete casting work was also hampered by a shortage of skilled labor, while the installation of mechanical and electrical systems was delayed due to sudden design changes. These issues not only disrupted the project schedule but also had the potential to cause significant cost overruns if not addressed with effective management strategies (Hermansyah et al., 2022).

To address these issues, this research utilizes the Time Cost Trade Off (TCTO) method (Abdilah et al., 2021; Abdillah & Kurniawan, 2022). The TCTO method is used to analyze project time acceleration options by taking into account the additional costs that may be incurred, assisting in identifying optimal acceleration measures and Microsoft Project software is used to assist in the identification of project critical trajectories (Anggraeni et al., 2019). By identifying critical trajectories, project managers can focus on those activities that have the greatest impact on the overall schedule and accelerate those activities to reduce the total duration of the project (Pratiwi et al., 2022).

In addition to the TCTO method, there are several other methods that can be used to accelerate a project, namely the crashing method involves adding resources to critical path activities to reduce the duration of these activities, although this will usually increase costs (Sulistyo et al., 2023; Sulistyo & Al Fikri, 2021). The fast tracking method changes some activities that should be done sequentially to be done in parallel, thereby reducing the total project completion time without significant additional costs. The use of these two methods requires in-depth analysis to balance between time savings and cost increases (Afrizal, 2018; Waney & Ruitan, 2022).

In addition to Microsoft Project, critical paths can also be identified using tools and techniques, namely Primavera P6 is project management software that is often used for large and complex projects, PERT (Program Evaluation and Review Technique) is a project management technique that uses network diagrams to analyze the tasks involved in completing a project (Ulfa & Suhendar, 2021). CPM (Critical Path Method) is a project management method that helps in determining the sequence of activities that must be completed on time so that the project is completed on schedule (Pramesti & Listyawan, 2023; Zanri et al., 2023).

This research aims to produce practical recommendations and optimal solutions for project managers in managing time and cost acceleration (Nugroho et al., 2023). The expected results include identification of critical trajectories, analysis of time acceleration options and their impact on costs, and recommendations for effective acceleration strategies with minimal additional costs. Using MS Project, this research also provides practical guidance in project planning and management (Mariani & Witjaksana, 2019). Through this comprehensive approach, the research is expected to make a significant contribution in improving the efficiency and effectiveness of construction project management, particularly in the context of silo structure repair in Surabaya (Akbar, 2022).

This research aims to provide practical solutions in overcoming project delays and cost escalation. Therefore, research with the title "Analysis of Time and Cost Acceleration Using Time Cost Trade Off Method on Wheat Silo Structure Repair Project and Pellet Silo Phase III in Surabaya" is important to support the success of this project (Fazri et al., 2020). Based on the background described above, the purpose of this study is to determine what is the fastest time to work on the wheat silo structure repair project and pellet silo phase III (Ashari, 2023; Burhanudin, 2022).

2. RESEARCH METHODS

2.1. Research Subjects

Analysis of time and cost acceleration of construction project work using the time cost trade off method (Ariesty & Nauval, 2020).

2.2. Research Objective

In this study, the object of research on the project repair structure of wheat silo and pellet silo phase III at PT. ISM Bogasari Surabaya.

2.3. Research Location

Below is the research location of the wheat silo and pellet silo structure repair project phase III PT. ISM Bogasari Surabaya, East Java

2.4. Data Collection Procedure

In this study using secondary data taken by the author directly at : PT Ting Tai Konstruksi Indonesia, the data taken is S curve data, namely information about the project schedule which includes a complete list of activities, time estimates, and the order of dependence between activities.

Project cost plan and budget (RAB) data. This data includes cost estimates provided by the project team directly responsible for project implementation. This data is needed to calculate the additional cost of work on the alternative of adding overtime hours on work experiencing a critical trajectory and Normal Labor Wages per month to calculate the cost of acceleration with the addition of working hours (overtime). And Secondary data is supporting data in the form of literature related to the author's research, this literature can be in the form of books, lecture notes, journals related to the author's research.

2.5. Data Analysis Method

Analyze with the Time Cost Trade Off method to calculate the optimal time (Acceleration of time using the alternative of adding overtime hours).

3. RESULTS AND DISCUSSION

3.1. Research Results

3.1.1. Data Description

The collection was obtained through primary data derived from contractor reports, as follows:

Job Title	: Wheat Silo and Pellet Silo Phase III Structure Repair Works
Implementing Contractor	: PT Ting Tai Konstruksi Indonesia
Supervision Consultant	: PT Gunawan Cipta Arsindo
Contract Value	: 28,011,000,000 (Twenty Eight Billion Eleven Million Rupiah)
Implementation Time	: 455 calendar days (February 27, 2023 - May 26, 2023)
Work Location	: Jl. Nilam Timur No. 16 Tanjung Perak, Surabaya

3.1.2. Project Scheduling Data

In carrying out project scheduling, project scheduling data must be as detailed as possible to make it easier to determine the period of time the project activities must be completed. In this case, scheduling is a very important factor in accelerating the project. In the wheat silo and pellet silo structure repair project phase III, the project work takes 455 days starting on February 25, 2023 to May 26, 2024.

The following is data on the duration of work on the wheat silo structure repair project and pellet silo phase III.

Table 1. Work Duration

No	Activities	Activity Code	Duration (Days)
	Preparation & Administration		435
1	Mobilization and demobilization	1.1	453
	Directors	1.2	420
	Temporary Equipment	1.3	415
	Administration and reporting	1.4	420
	Insurance	1.5	7
2	Work Safety	1.6	425
	Old Grain Silo (A)		435
	Outer Silo (Silo 1)		150
	Gondola + Labor	2.1	18
	Temporary Work + Garbage Cleaning	2.2	18
	Inner Silo (Silo 2)		
	Installation of Work Platform	2.3	38
	Platform Lifting + Gondola + Labor	2.4	38
	Temporary Work + Garbage Cleaning	2.5	150
	Silo Roof (Silo 3)		150
	Removal of Existing Screed + Installation of Watertightness	2.6	150
	Temporary Work + Rubbish Clearance	2.7	150
	Outside of Silo (Silo 4)		
	Cracks	2.8	150
	Concrete Spillage (up to 50mm)	2.9	150
	Open Reinforcement	2.10	150
	Rebar	2.11	150
3	Chemical Injection D10 @50 cm Reinforcement Joint (Fisher Vis VT)	2.12	150
	Coating	2.13	150
	Inner Silo (Silo 5)		135
	Cracks	2.14	135
	Concrete Spillage (up to 50mm)	2.15	135
	Open Reinforcement	2.16	135
	Rebar	2.17	135
	Chemical Reinforcement Connection D10 @50 cm	2.18	135
	Silo Roof (Silo 6)		
	Cracks	2.19	135
	Uneven Surface Repair	2.20	135
	Watertight Installation	2.21	135
	Using Ready Pack + Wiremesh M2	2.22	135
	Sealant	2.23	135

No	Activities	Activity Code	Duration (Days)
	New Grain Silo (B)		375
	Outside of Silo (Silo 1)		125
	Gondola + Labor (certified)	3.1	125
	Temporary Work + Garbage Cleaning	3.2	125
	Inside of Silo (Silo 2)		
	Installation of Work Platform	3.3	125
	Gondola + Labor (certified)	3.4	125
	Temporary Work + Garbage Cleaning	3.5	125
	Silo Roof (Silo 3)		125
	Gondola + Labor (certified)	3.6	125
	Removal of Existing Screed + Installation of Waterproofing	3.7	125
	Temporary Work + Rubbish Clearance	3.8	125
	Outside of Silo (Silo 4)		
	Cracks	3.9	125
	Concrete Spillage (up to 50mm)	3.10	125
	Open Reinforcement	3.11	125
	Rebar	3.12	125
4	Chemical Injection of D10 @50 cm Reinforcement Joints (Fisher Vis VT)	3.13	125
	Coating	3.14	125
	Silo Interior (Silo 5)		125
	Cracks	3.15	125
	Concrete Spillage (up to 50mm)	3.16	125
	Open Reinforcement	3.17	125
	Rebar	3.18	125
	Chemical Reinforcement Connection D10 @50 cm	3.19	125
	Crack	3.20	125
	Uneven Surface Repair	3.21	125
	Old Pellet Silo (A)		420
	Outside of Silo (Silo 1)		140
	Gondola + Labor (certified)	4.1	140
	Temporary Work + Garbage Cleaning	5.5	120
	Silo Roof (Silo 3)		120
	Gondola + Labor (certified)	5.6	120
5	Removal of Existing Screed + Installation of Waterproofing	5.7	120
	Temporary Work + Garbage Cleaning	5.8	120
	Outer Silo (Silo 4)		
	Cracks	5.9	120
	Concrete Spillage (up to 50mm)	5.10	120

No	Activities	Activity Code	Duration (Days)
	Open Reinforcement	5.11	120
	Rebar	5.12	120
	Chemical Injection D10 @50 cm Reinforcement Joint (Fisher Vis VT)	5.13	120
	Coating	5.14	120
	Silo Interior (Silo 5)		120
	Crack	5.15	120
	Concrete Spillage	5.16	120
	Open Reinforcement	5.17	120
	Rebar	5.18	120
	Chemical Injection of 10 mm diameter rebar @50 cm	5.19	120
	Silo Roof (Silo 6)		
	Cracks	5.20	120
	Uneven Surface Repair	5.21	120
	Mat Foundation		200
	Cracks	5.22	200
	Concrete Spillage (up to 50mm)	5.23	200
	Cracks	5.20	120
	Uneven Surface Repair	5.21	120
	Mat Foundation		200
	Cracks	5.22	200
	Concrete Spillage (up to 50mm)	5.23	200
	Open Rebar	5.24	200
	Rebar	5.25	200
6	D10 @50 cm Reinforcement Connection	5.26	200
	Coating	5.27	200
	Repair of Pore Hole Closure on Concrete Surface	5.28	200

Source: Processed Research Results, 2024

Based on the table above is a table listing the duration of the wheat silo and pellet silo structure repair project phase III. By using the duration table, it can estimate the project implementation schedule more accurately, identify critical activities that have a major impact on the overall schedule, and plan time acceleration strategies if needed. In addition, the duration table can also be the basis for conducting Time Cost Trade Off analysis, where it can consider time acceleration options with associated additional costs.

3.1.3. Additional Working Hours (Overtime)

When adding working hours (overtime) the productivity of workers per hour changes, such as when adding working hours (overtime) 1 hour per day, the productivity is calculated at 90%, 2 hours per day the productivity is 80% for the acceleration of the duration of critical activities calculated based on the addition of working hours (overtime) from the existing normal duration. The calculation example is below:

a. Duration crashed based on the addition of 1 hour of overtime on the inside of Silo (Silo 5) for the old wheat silo to repair the crack:

Volume = 7500,00 m1
Normal duration= 135 days

$P_h = \frac{V}{Tn} = \frac{7500,00}{135} = 55,56\ m^1$ / days

$P_j = \frac{Ph}{J} = \frac{55,56}{8} = 6,94\ m^1$/hours

$P_c = (W \times Pj) + (a \times b \times Pj)$
$= (8 \times 6,94) + (1 \times 0,9 \times 6,94)$
$= 61,77\ m^2$/ days

$D_c = \frac{V}{Pc} = (7500,00)/61,77$
$= 121,43 = 121$ days

Table 2. Recapitulation of Crash Duration Calculation Results on Addition of 1 Working Hour

Code	Normal Duration (Days)	Craching Duration (Days)	Code	Normal Duration (Days)	Craching Duration (Days)
2.1	18	16	2.13	150	135
2.2	18	16	2.14	135	121
2.3	38	34	2.15	135	121
2.4	150	135	2.16	135	121
2.5	38	34	2.17	135	121
2.6	38	34	2.18	135	121
2.7	38	34	2.19	135	121
2.8	150	135	2.20	135	121
2.9	150	135	2.21	135	121
2.10	150	135	2.22	135	121
2.11	150	135	2.23	135	121
2.12	150	135			

Source: Researcher's Processed Results, 2024

For old wheat silos where the work is in the form of repairing silos 1 - silo 2 with a normal duration of 150 days after adding 1 hour of overtime to 135 days Also for silo 3 - silo 4 work after a normal duration of 150 days with the addition of 1 hour of overtime to 135 days for silo 5- silo 6 work with a duration of 135 days after adding 1 hour of overtime to 121 days. So, the results of the calculation of Crash Duration 1 hour for activities that are on the critical trajectory or old grain silo repair activities, namely from the normal time of 455 after the calculation of Crash Duration 1 hour to 391 days.

b. The duration is crashed based on the addition of 2 hours of overtime on the inside of the Silo (Silo 5) for the old wheat silo to repair the crack:

Volume = 7500,00 m^1
Norm durationl = 135 hari

$P_h = \frac{V}{Tn} = \frac{7500,00}{135} = 55,56\ m^1$ / days

$P_j = \frac{Ph}{J} = \frac{55,56}{8} = 6,94\ m^1$/hours

$Pc = (W \times Pj) + (a \times b \times Pj) + (a \times b \times Pj)$
$= (8 \times 6,94) + (1 \times 0,9 \times 6,94)\ ) + (1 \times 0,8 \times 6,94)$
$= 67,32\ m^1$/hari

$D_c = \frac{V}{Pc} = \frac{7500,00}{67,32} = 111,\ 41 = 111$ days

Table 3. Recapitulation of Crash Duration Calculation Results on Addition of 2 Working Hours

Kode	Durasi Normal (Hari)	Durasi *Craching (Hari)*	Kode	Durasi Normal (Hari)	Durasi *Craching (Hari)*
2.1	18	15	2.13	150	124
2.2	18	15	2.14	135	111
2.3	38	31	2.15	135	111
2.4	150	124	2.16	135	111
2.5	38	31	2.17	135	111
2.6	38	31	2.18	135	111
2.7	38	31	2.19	135	111
2.8	150	124	2.20	135	111
2.9	150	124	2.21	135	111
2.10	150	124	2.22	135	111
2.11	150	124	2.23	135	111
2.12	150	124			

Source: Researcher's Processed Results, 2024

For the old wheat silo where the work is in the form of repairing silo 1- silo 2 with a normal duration of 150 days after adding 2 hours of overtime to 124 days Also for silo 3 - silo 4 work after a normal duration of 150 days with the addition of 2 hours of overtime to 124 days for silo 5- silo 6 work with a duration of 135 days after adding 2 hours of overtime to 111 days. So, the results of the calculation of Crash Duration 2 hours for activities that are on the critical trajectory or old grain silo repair activities are from the normal time of 455 after the calculation of Crash Duration 1 hour to 359 days.

4. CONCLUSION

By using Microsoft project software on the project repair wheat silo structure and pellet sillo phase III in Surabaya, it is known that the critical trajectory is in mobilization and demobilization activities, administration and reporting, work safety and repair of old wheat silos. Based on the results of the TCTO calculation, the project repair of the wheat silo structure and pellet silo phase III in Surabaya obtained the fastest completion time in 359 days from the normal time of 455 days, a decrease in time of 21.10% from the normal time. The time reduction is obtained from the addition of working hours (overtime) 2 hours every day with an additional cost of Rp.739,351,125.00. or 2.64% of the project value.

Based on the results of the study, several suggestions can be found, namely by being able to examine structural details and specific construction techniques not discussed in this study, in order to get a more comprehensive picture of the project. Future research can consider the addition of labor and the use of heavy equipment as an alternative to accelerating time in addition to the addition of overtime hours. It is also recommended to conduct a more in-depth evaluation of the impact of time acceleration on overall project performance. This includes an assessment of the quality of work, work safety, and the long-term impact on the repaired structure.

REFERENCES

Abdilah, M. T., Puspita, I. A., & Tripiawan, W. (2021). Perancangan Waktu Dan Biaya Proyek Rehabilitasi Sekolah Menggunakan Metode Cpm Dan Time Cost Trade Off. *EProceedings of Engineering*, *8*(6).

Abdillah, M. G., & Kurniawan, S. (2022). Analisis Metode Time Cost Trade Pada Pembangunan Perpustakaan Iain Metro. *JUMATISI: Jurnal Mahasiswa Teknik Sipil*, *3*(1), 211–218.

Afrizal, A. I. (2018). *Time Cost Trade Off Analisys Untuk Pengoptimalan Waktu dan Biaya Proyek (Studi Kasus: Pembangunan UPT Puskesmas Karangpucung)*.

Akbar, Y. R. (2022). Penentuan Jalur Kritis untuk Manajemen Proyek (Studi Kasus Pembangunan Jalan Selensen-Kota Baru-Bagan Jaya). *Jurnal Pustaka Manajemen (Pusat Akses Kajian Manajemen)*, *2*(1), 6–13.

Anggraeni, D. N., Nugroho, M. W., & Sumarsono, S. (2019). Optimasi Waktu dan Biayacrashing dengan Menggunakan Metode Time Cost Trade Off. *Civilla: Jurnal Teknik Sipil Universitas Islam Lamongan*, *4*(2), 310–317.

Ariesty, A., & Nauval, M. R. (2020). Analisis Penerapan Metode Jalur Kritis pada Proyek Pembangunan Gedung Pengelolaan RTH Cangehgar. *JTERA (Jurnal Teknol. Rekayasa)*, *5*(1), 2019–2025.

Ashari, N. F. (2023). Analisis optimasi waktu dan biaya proyek dengan metode time cost trade off dan fast track pada pekerjaan penanganan longsor. *Jurnal Proyek Teknik Sipil*, *6*(2), 21–29.

Burhanudin, M. S. (2022). *Analisis Percepatan Waktu Pada Pekerjaan Sipil Proyek Pembangunan Lpg Refrigerated Dengan Menggunakan Metode Critical Path Method (Cpm) Dan Time Cost Trade Off (TCTO)*. Universitas Islam Sultan Agung.

Fazri, M., Widiastuti, M., & Jamal, M. (2020). Analisis Percepatan Waktu Dengan Menggunakan Metode Time Cost Trade Off Pada Proyek Pembangunan Rusun 1 Kota Samarinda Kalimantan Timur. *Teknologi Sipil: Jurnal Ilmu Pengetahuan Dan Teknologi*, *3*(2), 1–14.

Hermansyah, H., Umar, T. D. J., & Rasdiati, R. (2022). Pemanfaatan Bonggol Jagung

Sebagai Bahan Tambah Dalam Campuran Beton. *Jurnal Kacapuri: Jurnal Keilmuan Teknik Sipil*, *5*(1), 131–139.

Mariani, R., & Witjaksana, B. (2019). *Analisis Crashing Time Menggunakan Ms-Project Dalam Pelaksanaan Pekerjaan Pada Proyek Peningkatan Jalan.”*. SpTS: Jurnal Spesialis Teknik Sipil.

Nugroho, D., Marleno, R., & Tjendani, H. T. (2023). Optimasi Waktu Dan Biaya Proyek Revitalisasi Pasar Kraton Kota Tegal. *Jurnal Spesialis Teknik Sipil (JSpTS)*, *3*(1), 24–41.

Pramesti, H. R., & Listyawan, A. B. (2023). Analisa Pengendalian Waktu dengan Metode Critical Path Method (CPM) pada Proyek Pembangunan Pondok Iqro’, Surakarta. *Prosiding Seminar Nasional Teknik Sipil UMS*, 560–566.

Pratiwi, R., Devi, S. M., Marini, A., & Sari, H. M. (2022). Optimasi Waktu Dan Biaya Dengan Metode Time Cost Trade Off (Tcto) Pada Proyek Penambahan Bangunan Pasar Rakyat: Time And Cost Optimization Using The Time Cost Trade Off Method In The People’s Market Additional Building Project. *Jurnal Ilmiah Teknik Sipil TRANSUKMA*, *4*(2), 93–105.

Sulistyo, A. B., & Al Fikri, M. (2021). Analisis Optimalisasi Waktu Dan Biaya Proyek Konstruksi Menggunakan Metode Time Cost Trade Off. *Jurnal Intent: Jurnal Industri Dan Teknologi Terpadu*, *4*(1), 25–40.

Sulistyo, A. B., Kusdianto, A., & Wirawati, S. M. (2023). Analisis Manajemen Proyek dengan Sistem Umbrella Contract Menggunakan Metode Time Cost Trade Off (Studi Kasus: PT Jaya Inti Teklindo). *Jurnal Penelitian Dan Aplikasi Sistem Dan Teknik Industri (PASTI)*, *17*(1), 43–57.

Ulfa, S., & Suhendar, E. (2021). Implementasi Metode Critical Path Method Pada Proyek Synthesis Residence Kemang. *Jurnal Optimasi Teknik Industri (JOTI)*, *3*(1), 1–6. https://doi.org/10.30998/joti.v3i1.4167

Vebiola, N. E., & Waskito, J. P. H. (2020). Analisis Optimasi Waktu Dan Biaya Dengan Metode Time Cost Trade Off (Studi Kasus: Proyek Pembangunan Basement Kawasan Balai Pemuda). *Axial: Jurnal Rekayasa Dan Manajemen Konstruksi*, *8*(2), 113–120.

Waney, E. V. Y., & Ruitan, S. M. (2022). Perencanaan Waktu dan Penjadwalan Pelaksanaan Proyek Pembangunan Rusun TNI di Minahasa Utara. *Prosiding Seminar Nasional Produk Terapan Unggulan Vokasi*, *1*(1), 290–295.

Zanri, I. F., Santosa, A. W. B., & Mulyatno, I. P. (2023). Optimalisasi Penjadwalan Ulang Perbaikan Kapal Hiu Macan Tutul 02 dengan Menggunakan Metode CPM. *Jurnal Teknik Perkapalan*, *11*(1), 72–78.

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