

PROJECT SCHEDULING USING THE CPM AND PERT METHODS IN THE CONSTRUCTION PROJECT OF THE GORONTALO STATE UNIVERSITY LABORATORY

Faizal Addin Achmad¹, Gali Pribadi²

^{1,2}Civil Engineering Study Program, Krisnadwipayana University
Email : galipribadi@unkris.ac.id

ABSTRACT

Project implementation requires careful planning, scheduling, and management, covering aspects such as resources, materials, equipment, natural conditions, weather, and other factors that affect project progress. This planning describes the interrelationships between activities throughout the entire project sequence and helps establish priorities. In this study, the Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT) were used, which differ from the approach used in the construction of the Gorontalo State University laboratory. Calculations were performed using Microsoft Project software. The analysis results indicate that six work items are on the critical path: preparation work, lower structure, upper structure, architecture, hardscape, and softscape. The estimated project completion duration is 105 days using CPM and 101 days using PERT, with a success probability of 37.37%.

Keywords: Projects, Laboratories, CPM, PERT

INTRODUCTION

Project implementation requires proper planning, scheduling, and management, covering aspects such as resources, material availability, equipment, natural conditions, climate, and other factors that could potentially affect project development. These factors not only affect progress but can also cause delays and deviations from the completion schedule. Disruptions in project implementation can hinder the achievement of objectives, ultimately leading to wasted time and costs. Project planning illustrates the interrelationships between activities in the entire work sequence and helps establish priorities. Various approaches can be used in scheduling analysis, and this study applies the Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT), which show differences compared to planning methods in the construction project of the Gorontalo State University laboratory.

METHODS

The researchers conducted the study over a period of two months, beginning with initial observations and continuing through data collection and analysis. During this period, various field data were systematically collected to ensure accurate and representative research results. The location of the research object was an important focus of this study, as can be seen in the image below, which shows the location of the research activities that were carried out.

**Figure 1. Research Location**

The data collection method used was to search for information related to the construction of the Gorontalo State University laboratory. The data required in this study included secondary data, such as S-curve graphs or time schedules, as well as supporting data from other projects. Data processing is an important step in analyzing the information obtained. Data analysis in this study focused on the time period of the Gorontalo State University laboratory construction project by applying the CPM and PERT methods. After the data was collected, the processing was carried out using Microsoft Project software.

RESULTS AND DISCUSSION

Critical Path Method (CPM) analysis involves calculating the duration of each project activity by considering time parameters such as early start (earliest start time), early finish (earliest finish time), latest start (latest start time), and latest finish (latest finish time). This process involves forward pass and backward pass calculations, as well as total float calculations to determine the time slack for each activity. The main purpose of this analysis is to identify the critical path—that is, the sequence of activities that have no time slack and must be completed on time to prevent project delays. The initial step in this process begins with assigning activity codes to each task in the project sequence.

Table 1. Types of Task Codes

No.	Type of Activity	Activity Code
1	Preparatory work	A
2	Substructure	B
3	Superstructure	C
4	Architecture	D
5	Hardscape	E
6	Softscape	F
7	Mechanical	G
8	Electrical	H
9	Plumbing	I

The next step in the planning process for the Gorontalo State University laboratory construction project is to determine the duration or time frame required to complete each work activity in detail. This is done so that all stages of work can be arranged in a realistic and measurable implementation schedule, as well as to ensure the availability of resources and integration between activities so that there are no delays in the completion of the project.

Table 2. Work Time

No.	Type of Activity	Duration (days)
1	Preparatory work	101
2	Substructure	57
3	Superstructure	67
4	Architecture	77
5	Hardscape	87
6	Softscape	87
7	Mechanical	100
8	Electrical	98
9	Plumbing	87

In preparing the project schedule, the initial step is to determine the duration of each task, then logically link all activities based on their sequence and interdependencies. To analyze task durations and identify the project's critical path, the author utilized Microsoft Project software. Once all information and technical data had been collected, the next step was to input the data into Microsoft Project. Based on the scheduling analysis results, the construction project for the Gorontalo State University laboratory is estimated to be completed within 101 calendar days. The results of this schedule modeling can be visualized in the form of a bar chart (Gantt Chart) and a network diagram (Network Diagram), which provide a comprehensive overview of the sequence of implementation and relationships between activities within the project.


Figure 1. CPM Network Diagram

Based on the figure above, it is known that there are six work items included in the critical path, which directly affect the overall project completion time. To estimate the likelihood of achieving the project completion time target, an analysis was performed using the PERT (Program Evaluation and Review Technique) method. Unlike the CPM method, which uses a single time estimate (deterministic), PERT uses a probabilistic approach with three types of duration estimates, namely:

- 1) Best time (A);
- 2) Worst time (B);
- 3) Most likely time (M).

The analysis results produced three scenarios for estimating the completion time of the Gorontalo State University laboratory construction project: optimistic, realistic, and pessimistic. These three estimates provide a more comprehensive picture of the possible duration of the project, which can be used as a basis for more accurate decision-making in project planning and time control.

Table 3. Work Duration Calculations Processed Using the PERT Method

No.	Type of Activity	Activity Code	A	M	B
1	Preparatory work	A	101	102	103
2	Substructure	B	113	115	121
3	Superstructure	C	113	115	121
4	Architecture	D	87	91	111
5	Hardscape	E	23	25	37
6	Softscape	F	21	27	25
7	Mechanical	G	105	107	109
8	Electrical	H	105	107	109
9	Plumbing	I	105	107	109

The purpose of establishing relationships between activities is to identify and understand the logical connections between activities that have been completed and those that will be carried out. In the Gorontalo State University laboratory construction project, each activity has dependencies that form a series of tasks. The sequence of activities is arranged based on the interdependencies between activities to ensure the smooth flow of the entire project.

Table 4. Interrelationships between Types of Work Implementation

No.	Type of Activity	Activity Code	duration	Previous Work
1	Preparatory work	A	101	-
2	Substructure	B	113	A start to start + 15 days
3	Superstructure	C	113	B start to start + 97 days
4	Architecture	D	87	C start to start + 21 days
5	Hardscape	E	23	D finish to start + 79 days
6	Softscape	F	21	E finish to start + 88 days
7	Mechanical	G	105	G start to start + 71 days
8	Electrical	H	105	H finish to start + 95 days
9	Plumbing	I	105	H finish to start – 101 days

In the process of developing a project schedule, the first step is to determine the duration of each task, followed by arranging the sequence of activities based on the logical interdependencies between tasks. The author utilized Microsoft Project software to analyze task durations and identify the critical path that impacts project completion time. Once all required information was successfully collected, the data was entered into the Microsoft Project system for scheduling. Based on the analysis results, the construction project for the Gorontalo State University laboratory is projected to be completed within 101 days. The analyzed schedule can be visualized through a bar chart and a network diagram, providing a comprehensive overview of the project's activity flow.

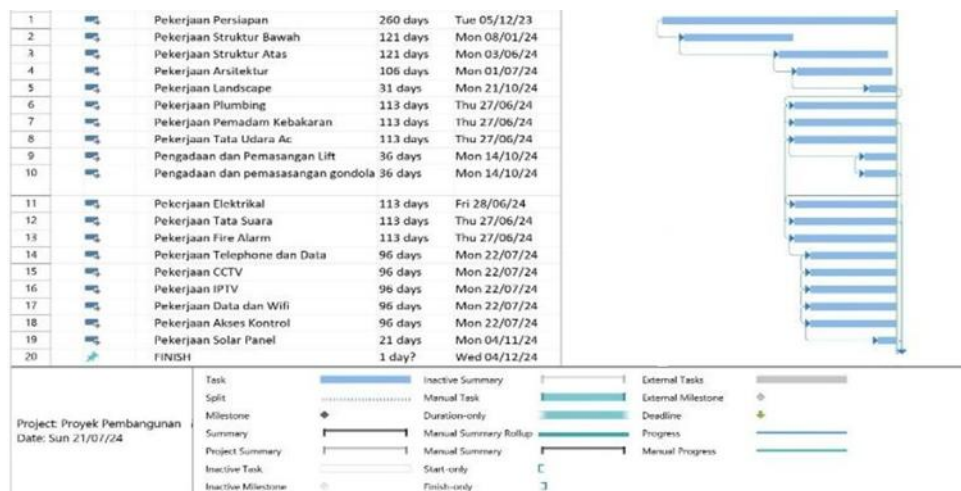


Figure 2. CPM Scheduling Using MS Project

After obtaining the standard deviation value, the next step is to calculate the probability of successfully completing the Gorontalo State University laboratory construction project according to the planned schedule.

$$Z = \frac{T(d) - T_e}{s}$$

$$Z = \frac{101 - 102}{6}$$

$$Z = -0,1667$$

CONCLUSIONS

Based on the results of the analysis conducted, six work items were identified as part of the critical path of the Gorontalo State University laboratory construction project. These items include:

- 1) Preparatory work as the initial stage of project implementation;
- 2) Substructure work, including foundation work and other supporting elements;
- 3) Superstructure work, including building frames and main structural elements;
- 4) Architectural work focused on the design and aesthetic aspects of the building;
- 5) Hardscape and softscape work, including hard landscape elements such as pathways and sidewalks, and soft landscape elements such as gardens and vegetation.

Based on calculations using the Critical Path Method (CPM), the project is estimated to be completed in 105 days. However, using the Program Evaluation and Review Technique (PERT) approach, the estimated completion time is shorter, at around 101 days. Further probability analysis shows that the likelihood of the project being completed on time is 37.37%. These findings indicate the potential for delays that need to be carefully considered in the overall planning and management of the project.

REFERENCES

- Rumbyarso, Y. P. A., Budiman, A., & Setyowati, R. K. (2025). PERSPEKTIF HUKUM TERHADAP KEPAILITAN PERSEROAN TERBATAS DAN PERSEKUTUAN FIRMA. *YUSTISI*, 12(2).
- Rumbyarso, Y. P. A. (2025). DINDING PENAHAN TANAH Definisi & Fungsi Perencanaan.
- Rumbyarso, Y. P. A. (2025). Evaluasi Daya Dukung Pondasi Menggunakan Metode Poulus-Davis, Converse-Labbare Dan Mayerhof. *Jurnal Tera*, 5(1), 14-25.
- Hartanto, B. G., & Rumbyarso, Y. P. A. (2025). Kajian Produktivitas Alat Berat di Proyek Jalan Bebas Hambatan Serang-Panimbang KM 27+ 100 Sampai dengan 30+ 100. *Jurnal Ilmiah Universitas Batanghari Jambi*, 25(1), 794-799.
- Rumbyarso, Y. P. A. (2025). BUKU REFERENSI STRUKTUR JEMBATAN ANALISIS DAN APLIKASI.
- MUHAMMAD, R. I., & RUMBYARSO, Y. P. A. (2025). COMPRESSIVE STRENGTH ANALYSIS OF CONCRETE USING ASPHALT SCRAP WASTE. *INTERNATIONAL JOURNAL OF MULTI SCIENCE*, 5(01), 38-45.
- Rumbyarso, Y. P. A., ST, M., & MH, M. (2025). *BUKU AJAR MEKANIKA BAHAN*. Penerbit Widina.
- Darmiyanti, L., & Rumbyarso, Y. P. A. (2025). Optimizing electrokinetic clay soil improvement using calcium dioxide solutions: a comprehensive approach. *EUREKA: Physics and Engineering*, (2), 13.
- Rumbyarso, Y. P. A., Pribadi, G., & Achmad, F. A. (2025). EVALUASI DAN PENGEMBANGAN JEMBATAN UNTUK MENINGKATKAN KUALITAS DAN KEBERLANJUTAN DESTINASI WISATA. *KRIDA CENDEKIA*, 3(03).
- Rumbyarso, Y. P. A. (2024). Kajian Penurunan Tanah di Kabupaten Bekasi Akibat Eksploitasi Air Berlebihan dengan Aplikasi Geostudio dan Plaxis. *Qomaruna Journal of Multidisciplinary Studies*, 2(1), 42-56.

- Hartanto, B. G., & Rumbyarso, Y. P. A. (2024). ANALYSIS OF HEAVY EQUIPMENT PERFORMANCE ON THE PROBOLINGGO-BANYUWANGI TOLL ROAD PROJECT KM SECTION KM 09+ 125 TO KM 09+ 725. *INTERNATIONAL JOURNAL OF MULTI SCIENCE*, 4(03), 57-63.
- Achmad, F. A., & Rumbyarso, Y. P. A. (2024). PROJECT SCHEDULING WITH CPM AND PERT METHODS ON THE PT. JAKARTA INDUSTRIAL ESTATE PULOGADUNG MOSQUE CONSTRUCTION PROJECT. *INTERNATIONAL JOURNAL OF MULTI SCIENCE*, 4(03), 50-56.
- Rumbyarso, Y. P. A., & Setyowati, R. K. (2024). Perlindungan Hak Cipta Karya Aristektur Yang Beredar Bebas Di Internet. *Innovative: Journal Of Social Science Research*, 4(6), 7293-7301.
- Rumbyarso, Y. P. A. (2024). Aplikasi Perangkat Lunak Plaxis dan Geostudio dalam Studi Subsiden Tanah di Kecamatan Tarumajaya akibat Pemanfaatan Air Tanah Berlebih. *Jurnal Teknologi dan Sains Modern*, 1(3), 110-119.
- Pribadi, G., & Rumbyarso, Y. P. A. (2024). Model Perkuatan Anyaman Bambu pada Subgrade Bungker Tangki Pendam. *Jurnal Ilmiah Universitas Batanghari Jambi*, 24(3), 2530-2535.
- Pribadi, G., & Rumbyarso, Y. P. A. (2024). ANALISIS UJI TEKAN BETON MENGGUNAKAN BAHAN LIMBAH KARET DILATASI KONDISI CURING DENGAN AIR LAUT. *Jurnal Konstruksi Teknik Sipil*, 1(3), 203-213.
- Yonas, P. (2024). Kajian Peralatan Berat Pada Proyek Konstruksi.
- Rumbyarso, Y. P. A., & Pribadi, G. (2024). Analisis Kapasitas Daya Dukung Bore Pile Pada Proyek Gedung Fakultas Hukum Unisulla Semarang Jawa Tengah. *Pasak: Jurnal Teknik Sipil dan Bangunan*, 2(1), 1-5.
- Farhan, M. F. F., Rumbyarso, Y. P. A., & Siagian, B. M. (2024). Analisa Penjadwalan Proyek Menggunakan CPM dan PERT Pada Proyek Pembangunan Gedung KONI Jakarta Pusat. *Jurnal Teknik dan Teknologi Indonesia*, 2(3), 1-11.
- Rumbyarso, Y. P. A., Pribadi, G., & Addin, F. (2024). PENGENALAN DAN PELATIHAN AUTOCAD UNTUK MENINGKATKAN KETERAMPILAN SISWA SMA YAPEMRI DEPOK. *KRIDA CENDEKIA*, 3(02).
- GIOVANNI, D., RUMBYARSO, Y. P. A., & SIAGIAN, B. (2024). ANALYSIS OF CONCRETE COMPRESSIVE STRENGTH WITH PARTIAL SUBSTITUTION OF IRON POWDER WASTE AS FINE AGGREGATE. *INTERNATIONAL JOURNAL OF MULTI SCIENCE*, 4(02), 122-129.
- RUMBYARSO, Y. P. A., & Pribadi, G. (2024). ANALYSIS OF CONCRETE COMPRESSIVE STRENGTH WITH COCONUT FIBER WASTE AS A PARTIAL REPLACEMENT OF FINE AGGREGATE. *INTERNATIONAL JOURNAL OF MULTI SCIENCE*, 4(02), 130-135.
- Ashshiddiq, F. R., Rumbyarso, Y. P. A., & Siagian, B. M. (2024). ANALYSIS OF FLEXURAL STRENGTH OF BEAM USING BAMBOO REINFORCEMENT. *INTERNATIONAL JOURNAL OF MULTI SCIENCE*, 4(02), 97-103.
- Wahyudi, T., Rumbyarso, Y. P. A., & Siagian, B. M. (2024). THE EFFECT OF FISH BONE POWDER WASTE AS A FINE AGGREGATE SUBSTITUTION IN ASPHALT CONCRETE WEARING COURSE PAVEMENT. *INTERNATIONAL JOURNAL OF MULTI SCIENCE*, 4(02), 63-69.
- Rinjoko, N. F., Rumbyarso, Y. P. A., & Darmiyanti, L. (2024). THE EFFECT OF GRANITE WASTE AS A FINE AGGREGATE SUBSTITUTION IN ASPHALT CONCRETE BINDER COURSE. *INTERNATIONAL JOURNAL OF MULTI SCIENCE*, 4(02), 56-62.
- Taqwa, I., Rumbyarso, Y. P. A., & Darmiyanti, L. (2024). ANALYSIS OF LIGHTWEIGHT BRICK WASTE FOR PARTIAL SUBSTITUTION OF FINE AGGREGATE ON CONCRETE COMPRESSIVE STRENGTH. *INTERNATIONAL JOURNAL OF MULTI SCIENCE*, 4(02), 34-41.
- Rumbyarso, Y. P. A., & Pribadi, G. (2024). Analysis of Landslide Handling With Mini Pile Reinforcement Using Plaxis Software on The "X" Toll Road Project. *Jurnal Teknik Industri Terintegrasi (JUTIN)*, 7(2), 801-810.

- Rumbyarso, Y. P. A. (2024). Analisis Perbandingan Kinerja Struktur Tahan Gempa Pada Wilayah Berbeda Dengan Metode Respon Spektrum (Studi Kasus: Apartemen 19 Lantai). *Pasak: Jurnal Teknik Sipil dan Bangunan*, 1(2), 69-72.
- Arga Rumbyarso, Y. P. (2024). Buku Ajar Struktur Beton Prestress.
- Rumbyarso, Y. P. A. (2023). IDENTIFIKASI KRITERIA KUAT GESER TANAH LEMPUNG DI DESA CIMUNCANG KABUPATEN MAJALENGKA. *Jurnal Tera*, 3(1), 47-54.
- Rumbyarso, Y. P. A., & Fariqi, A. (2024). Learning Obstacle On Integral (Antiderivative) Material In Didactic Situation Theory. *Larisa Teknik Sipil*, 1(1), 1-7.
- Abidin, Z., & Rumbyarso, Y. P. A. (2024). PCI-Analyzed Administrative Way Damage. *Larisa Teknik Sipil*, 1(1), 8-14.
- Rumbyarso, Y. P. A. R. A., & Pribadi, G. (2024). Re-Desain Elemen Dinding Geser Dan Kolom Pada Proyek Gedung. *Jurnal Tera*, 4(1).
- Rumbyarso, Y. P. A., & Pribadi, G. (2024). Analisis Kuat Lentur Balok Dengan Pemanfaatan Perkuatan Limbah Kulit Tebu Sebagai Alternatif Tulangan. *Jurnal Tera*, 4(2).
- Yonas Prima, A. R. (2024). MODUL AJAR MENGGAMBAR TEKNIK SEMESTER GENAP 2023/2024.
- Arga Rumbyarso, Y. P. (2024). Kinerja Struktur Gedung Office 36 Lantai: Analisis History dan Pushover.
- Achmad, F. A., & Rumbyarso, Y. P. A. (2024). Analisis Penjadwalan Proyek Klinik Spesialis Mata & Tht Ayani Dengan Pert & Cpm. *International Journal Of Multi Science*, 4(01), 1-8.
- Arga Rumbyarso, Y. P. (2023). Perhitungan Produktivitas Peralatan Berat pada Proyek Jalan Tol Semarang-Demak Seksi 1C Km 35+ 400 Sampai dengan 36+ 400. *Mechonversio; Mechanical Engineering Journal*, 6(2), 34-39.
- Rumbyarso, Y. P. A., & Pribadi, G. (2023). Analisis Stabilitas Lereng dengan Metode Bishop pada Proyek Geotechnical Investigation Jalur Transportasi Pelabuhan Batubara Marangkayu Kabupaten Kutai Kartanegara. *Jurnal Kridatama Sains Dan Teknologi*, 5(02), 562-577.
- Rumbyarso, Y. P. A., Pribadi, G., & Achmad, F. A. (2023). PENGENALAN DASAR-DASAR PENGOLAHAN DATA PADA SMK PGRI 4 JAKARTA MENGGUNAKAN APLIKASI SPSS. *Krida Cendekia*, 2(02).
- Rumbyarso, Y. P. A. (2022). Analisis Perkuatan Rangka Atap Baja pada Bangunan Gedung Heritage 1921 Menggunakan Software SAP 2000. *Jurnal Teknik Indonesia*, 1(1), 1-8.
- Prima, Y., & Darmiyanti, L. (2023). Analisis Kinerja Struktur Gedung Rusun TNI AU Halim Perdanakusuma Dengan Menggunakan Metode Pushover Analysis. *Jurnal Sipil Krisna*, 9(2), 26-35.
- Artiani, G. P., Rodji, A. P., Sihombing, S. M., Arga, Y. P., & Pribadi, G. (2023). PERENCANAAN SUMUR RESAPAN UNTUK PENGENDALIAN BANJIR DI WILAYAH KECAMATAN PASAR REBO, JAKARTA TIMUR. *Abdimas Galuh*, 5(2), 1008-1018.
- Pribadi, G., & Rumbyarso, Y. P. A. (2023). Analisis Perbandingan Daya Dukung dan Penurunan Pondasi Tiang Bor Dengan Perhitungan Manual dan Software ALLPILE. *Jurnal TESLINK: Teknik Sipil Dan Lingkungan*, 5(2), 16-20.
- Rumbyarso, Y. P. A. (2023). Re-planning of Concrete Structures in the Ngoro Dormitory Project in Surabaya. *Journal of Applied Science, Engineering, Technology, and Education*, 5(1), 15-24.
- Pribadi, G., Rumbyarso, Y. P. A., & Sakti, E. M. S. (2023). Pelatihan Merancang Gambar Dengan Aplikasi Autocad untuk Pembekalan Siswa SMK dalam Memasuki Dunia Kerja. *Media Abdimas*, 2(2), 52-56.
- Rumbyarso, Y. P. A. (2023). Penyuluhan Komposisi Campuran Beton untuk Jalan Tol. *Journal of Social Work and Empowerment*, 2(3), 137-144.
- Abdillah, S. R., Zulfikar, S., & Prima, Y. (2023). Pengaruh Limbah Cangkang Kerang Sebagai Substitusi Agregat Halus Terhadap Kuat Tekan Beton. *Jurnal Sipil Krisna*, 9(1), 39-48.
- Rumbyarso, Y. P. A. (2023). Kajian Bresing Baja dan Kolom Beton Sebagai Alternatif Shearwall. *Jurnal Tera*, 3(2), 62-70.
- Sihombing, S. M., Darmiyanti, L., & Prima, Y. (2023). Pengaruh Elektroosmosis Terhadap Kuat Geser Tanah Lempung. *PROSIDING Konferensi Nasional Teknik Sipil*, 17.

- Achmad, F. A., & Rumbyarso, Y. P. A. (2023). Analisis Struktur Slab On Pile terhadap Kontrol Lendutan pada Proyek Jalan Tol Kataraja. *Jurnal Pendidikan Tambusai*, 7(2), 13457-13467.
- Rumbyarso, Y. P. A., & Pribadi, G. (2023). Penggunaan Program Plaxis Dalam Studi Penelitian Perkuatan Geotextile Pada Kestabilan Lereng Buatan. *Jurnal Sipilkrisna*, 9(1), 22-26.
- Darmiyanti, L., Prima, Y., & Aldianto, M. A. (2023). Analisis borepile menggunakan metode Meyyerhoff dan Reese Wright. *Jurnal Sipil Krisna*, 9(1), 27-38.
- Gamaliel, B., & Rumbyarso, Y. P. A. (2022). PELATIHAN DESIGN GAMBAR DENGAN APLIKASI AUTOCAD 2D UNTUK SISWA/I SMK YAPPA DEPOK. *KRIDA CENDEKIA*, 1(09).
- ST, Y. P. A. R., & MT, M. (2022). *INFRASTRUKTUR PEMBAHARU Silica Fume in Asphalt Concrete-Wearing Course*. AMERTA MEDIA.
- Prima, Y., & Gedung, A. K. S. (36). Lantai Analisis Time History Dan Pushover.
- Arga Rumbyarso, Y. P. (2021). Pengukuran Kinerja Perusahaan PT. Ritra Cargo Indonesia Menggunakan Balanced Scorecard.
- Arga Rumbyarso, Y. P. (2021). Perencanaan Struktur Bangunan Atas (Upper Structure) Gedung STIE Bank BPD Jateng Kota Semarang. *Jurnal Teknokris*, 24(1), 1-7.
- Rumbyarso, Y. P. A., & Ulum, R. B. (2021). Analisis Pengaruh Penggunaan Cangkang Telur Bebek Ras Petelur Sebagai Filler Pada Campuran Aspal Beton. *Jurnal Teknologika*, 11(2), 115-124.
- Prima, Y. (2022). ANALISIS DAYA DUKUNG KAWASAN PENDIDIKAN STT WASTU KENCANA (STUDI KASUS GEDUNG STT WASTUKENCANA). *Jurnal Ilmiah Plano Krisna*, 18(1).
- Rumbyarso, Y., Chusna, N., & Khumaidi, A. (2022). Dissolved Oxygen Prediction of the Ciliwung River using Artificial Neural Networks, Support Vector Machine, and Streeter-Phelps. *Jurnal Ilmiah Merpati (Menara Penelitian Akademika Teknologi Informasi)*, 10(3), 180-190.
- Rumbyarso, Y. P. A. (2022). Analysis Of Compressive Strength Of Concrete By Using Slag Circum As A Concrete Aggregate Mix. *International Journal Of Multi Science*, 2(12), 35-46.
- Fransiscus, R., Sihombing, S. M., & Prima, Y. (2022). ANALISIS TEBAL PERKERASAN LENTUR PADA JALAN TOL AKSES MENUJU BANDARA INTERNATIONAL KERTAJATI. *Jurnal Sipil Krisna*, 8(1), 50-61.
- Rumbyarso, Y. P. A., & Pribadi, G. (2022). Penyuluhan Tentang Pentingnya Sebuah Kontruksi Bagunan Rumah Yang Baik Serta Tahan Gempa. *Krida Cendekia*, 1(08).
- Rumbyarso, Y. P. A. (2022). Analisis Perkuatan Rangka Atap Baja pada Bangunan Gedung Heritage 1921 Menggunakan Software SAP 2000. *Jurnal Teknik Indonesia*, 1(1), 1-8.