

Scheduling Time Analysis with Critical Path Method on the Work of Master Plan Review Consulting Services in K International Airport in West Java

Wien Dyahrini
Yayat Mulyati
Yanto Rachmat Iskandar
Mohd Haizam Saudi

DOI: <https://doi.org/10.37178/ca-c.23.1.381>

Wien Dyahrini, Widyatama University, Bandung, Indonesia
Email: wien.dyahrini@widyatama.ac.id

Yayat Mulyati, Widyatama University, Bandung, Indonesia

Yanto Rachmat Iskandar, Widyatama University, Bandung, Indonesia

Mohd Haizam Saudi, Widyatama University, Bandung, Indonesia

ABSTRACT

This research is based on the work of master plan review consulting services in K International Airport in West Java, conducted from February to June 2019. Project scheduling shows the relationship among activities, and the overall project identifies the relationship that must be prioritized among activities and shows realistic time estimates for each activity. CPM (Critical Path Method) assumes that the activity time is known with certainty so that only a one-time factor is needed for each activity. One of the advantages of CPM is that it is suitable for formulating, scheduling, and managing various activities in all jobs, as it provides an empirically constructed schedule. This study aims to apply the CPM method in the work of master plan review consulting services in K International Airport in West Java. The results show that scheduling using the CPM method obtained 18 weeks for implementing the master plan review consulting services in K International Airport in West Java to complete a series of work activities with a budget of Rp. 2,818,381,500. Meanwhile, the schedule planned by the executor of the master plan review consulting services in K International Airport in West Java is 20 weeks with a total budget of Rp. 3,131,535,000.

Keywords: CPM Method, Time Scheduling, Critical Path

Introduction

The success or failure of implementing construction projects is often due to the lack of planned project activities and ineffective control. The result is inefficient project activities. In addition, it can also cause delays, decrease the quality of work, and increase implementation costs. Delay in project completion is a very undesirable condition because this can harm all parties in terms of time and cost. Concerning production time and costs, companies must be as efficient as possible in using time in each activity to adjust costs according to planning. Projects generally have a deadline and outputs that must be produced, meaning that the project must be completed before or on time. However, in reality, a project does not always run according to the schedule that has been made. Many factors are causing this to happen; one example is the rain. The process of planning project activities is a vital issue. Activity planning is the basis for running, implementing, and completing the project in an optimal time. In the work of master plan review consulting services in K International Airport in West Java, many activities are not running optimally, and this must be reviewed whether there are problems from the management or other obstacles. The author is interested in researching the project scheduling by applying the CPM method and accelerating the implementation of the master plan review consulting services in K International Airport in West Java.

The formulations of the problem in this study are as follows; how is the application of the CPM method on the work of master plan review consulting services in K International Airport in West Java?; how is the result of the crashing project on the work of the master plan review consulting services in K International Airport in West Java?; What are the advantages and disadvantages of the project planning and scheduling method?

This study aims to determine the application scheduling of the CPM method on the work of master plan review consulting services in K International Airport in West Java.

The benefits obtained from this research are knowing the performance of each scheduling method of the CPM, providing an alternative to determine the method of preparing the project implementation schedule, and determining the method of preparing the project implementation schedule with a short time for projects that will be conducted in the future.

Critical Path Method (CPM)

CPM was developed in 1957 by J.E. Kelly of Remington Rand and M.R. Walker from DuPont to help build and maintain a chemical plant in Dupont[1, 2] The CPM solution adopted by Kelly was derived from "Linear Programming" and used "I-J" notation to describe the relationship between activities [3]. Currently, CPM scheduling is rarely found and is generally only discovered in academic papers where the calculations are done manually (Weaver, 2006).

CPM Calculation Technique

Activity on Arrow, often called CPM (Critical Path Method), consists of arrows and circles or squares. Arrows represent activities, while circles or squares represent events. The event at the beginning of the arrow is called "I," while the event at the end of the arrow is called "J" [4]

Each activity on the arrow is an integral part of all activities so that the "J" event of the previous activity is also the "I" event of the next activity[5].

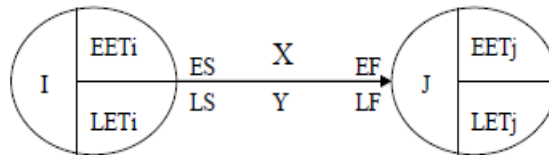


Figure 1. Activity on Arrow

- Where:
- i, j = Event number
 - X = Activity name
 - EET = Earliest Event Time
 - LET = Latest Event Time
 - Y = Activity duration
 - ES = Earliest Start Time
 - EF = Earliest Finish Time
 - LS = Latest Start Time
 - LF = Latest Finish Time

This method has the following characteristics[6]

- a. A network diagram is created using arrows to describe activities and their nodes to describe events. The node at the beginning of the arrow is designated as I-Node, while the one at the end of the arrow is designated as J-Node.
- b. Using forward calculations to obtain the earliest start time (EET_i) on the I-Node and the earliest start time (EET_j) on the J-Node of all activities by taking the maximum value. Here applies the notion that the earliest time the event occurred is = 0. The calculation is: $EET_j = EET_i + \text{duration } X$
- c. Using a countdown to get the latest finish time (LET_i) on the I-Node and the latest finish time (LET_j) on the J-Node of all activities by taking the minimum value. The calculation is: $LET_i = LET_j - \text{duration } X$
- d. Between two events, there cannot be two activities, so to avoid them, pseudo or dummy activities that have no duration are used.

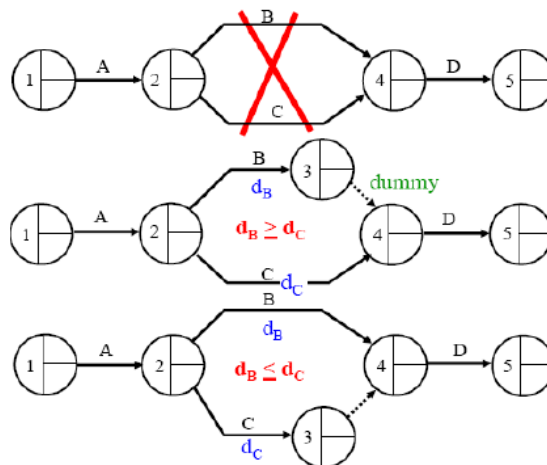


Figure 2. Pseudo or Dummy Activities

- e. Using the Critical Path Method (CPM), the deterministic approach only uses one duration type for the activity. The critical path is a collection of activities with the most prolonged duration that can be known if the activity has a Total Float (TF) = 0.
 - f. Float: the tolerance limit for delays in an activity that can be utilized for time optimization and resource allocation.
- There are three types of Floats, namely[6, 7]

a. TF (Total Float)

Maximum grace period in which an activity may be late without delaying the project completion time. It is helpful to determine the critical path, where TF = 0.

$$TF_{ij} = LET_j - EET_i - Duration_{ij}$$

b. FF (Free Float)

The maximum grace period is when an activity may be late without delaying its completion if it starts at the earliest time of its initial event. It is helpful for resource and time allocation by moving to other activities.

$$FF_{ij} = EET_j - EET_i - Duration_{ij}$$

c. IF (Independent Float)

The maximum grace period in which an activity can be late without delaying its completion if it starts at the latest of its initial event.

$$IF_{ij} = EET_j - LET_i - Duration_{ij}$$

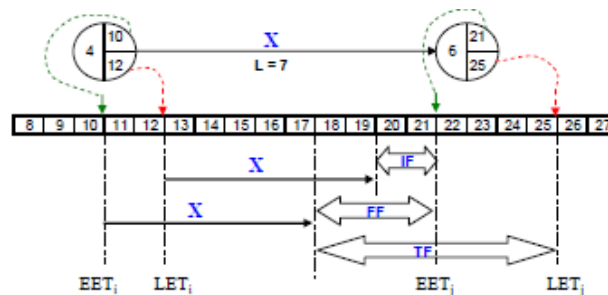


Figure 3. Float Variation of An Activity

The Disadvantage of CPM Method

The disadvantage of the CPM method is that it does not provide an efficient structure for the representation of repetitive tasks. All tasks are represented equally, and there is no consideration of job location in the schedule and requires the use of dummy activities as a technique that everyone does not readily understand to complete the network logic ([8-10]).

The CPM method is not suitable for representing and/or balancing the production rate of repetitive activities. Another weakness of the CPM method, according to [11] is that it only recognizes the finish-to-start relationship. Therefore, when applied to a multi-unit project, its use becomes ineffective because it contains too many relationships and creates a vast number of dummy activities[12].

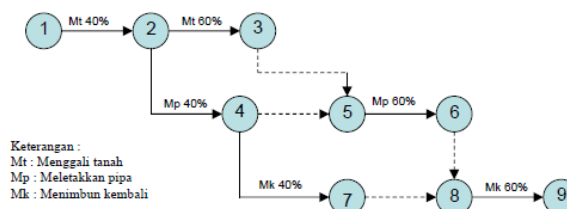


Figure 4. The Use of Dummy in CPM to Break Activities on Recurring Activities

Research Method

The method used in this research is the descriptive method. This descriptive research is research conducted by collecting as much data as possible based on the demand to present, interpret, analyze, and draw conclusions about the object's state

under study based on the obtained data. This needs to be conducted for acquiring solutions to be used as suggestions for companies as planners and project implementation.

Types of Data

In this study, the authors classify the data that has been collected into two groups:

1. Primary data are the central units to be processed in the research. These data were obtained directly from interviews with interested parties in the project and collecting project documents.
2. Secondary data were obtained through literature study, studying the literature, and the references needed and related to this research topic.

Steps of Research

The authors took steps in this study were, first, conducting a preliminary study, namely conducting interviews to find problems that would be used as background in the research. The second step is to formulate the existing problems to clarify them, make them more evident, and find suitable methods and solutions to overcome them. The third step is to collect information by conducting a literature study searching for sources and references to overcome existing problems. At last, the goal of the research is then reformulated. Then, the data collection process is conducted, which is necessary and appropriate for the typical research objectives; this is done in various ways, including collecting documents, interviewing, gathering literature studies, etc. The data will then be processed and analyzed using a predetermined method. Then, the solution will be obtained so that conclusions can be drawn from the research[13].

Research Object

In this research, the object is time planning for projects at PT X. PT X plays a vital role in applying research from science, technology, and art.

Data collection techniques were utilized in two ways, namely:

1. Field Research is direct research on the object under study to obtain primary data related to the topics discussed, employing interviews. Researchers conduct direct interviews with company leaders, employees, and other workers to obtain the desired data and follow the research objectives.
2. Library Research is research conducted to obtain data by using information and literature, company documents, such as company background, sequence of project activities and completion time of each activity, organizational structure, and other documents related to the current researched problem.

Research Variable

A variable is something that becomes the research observation objects or the factors that play a role in the event or symptom that will be studied [1, 14-17]. The variable in this study is scheduling planning for the project activities implementation, which can be seen from the table below:

Table 1

Research Variable

| Variable | Project Scheduling |
|-----------|--|
| Concept | Project scheduling is prepared to be a reference in project implementation and a basis for monitoring the implementation of the related project. Scheduling determines the time and sequence of the various stages and the relationship of one activity to another so that the total time duration of project completion is known. |
| Method | CPM Metode |
| Indicator | Project time efficiency |
| Size | A week |
| Scale | The difference in each week |

Analysis Method

After collecting data with several research techniques, the next step is to analyze the studied data by using methods that can assist in managing data, analyzing, and interpreting the data. The method used to analyze the research data on the work of the master plan review consulting service on K International Airport in West Java is the CPM method. The analytical method used in this study is to use the CPM approach. The estimated time for completing a project can be determined utilizing a single duration estimate or a single estimate of time (duration) for each activity (using the CPM approach).

The complete systematics in the preparation of network planning or working network according to [4, 18, 19] are:

1. Inventorying activities in this step, conducting an assessment, identifying the project scope, describing, and dividing them into groups of project-component activities
2. Rearranging activities into a chain, the sequence according to the dependency logic in network planning, the activity sequence link according to the dependency logic is the basis for network planning development, so the sequence of activities from the beginning to the end of the project is known completely.
3. Developing a network diagram that connects all activities. In this step, the activity relationships compiled in the second item are arranged into links in a sequence that follows the dependency logic.
4. Assigning time for each activity, arranging it into a network diagram, and providing a timeframe for each resulting activity according to the project scope, as in the first step. After the preparation of the estimated period for each activity is complete, the next step is to describe
5. the network that can connect all of the activities to be conducted. The relationship is depicted in a network diagram.
6. Identifying the critical path in the network diagram, which is compiled in the third step, and then forward and backward calculations are conducted from the two calculations.

Results and Discussion

In the form of project work and weights from the S Curve, secondary data will be identified and broken down into smaller components (work breaking down structure)

to obtain greater detail. The more detailed the activity, the more detailed its relationship with other activities. The S curve in the figure is an estimate of the overall project schedule made by PT X [7, 20, 21].

Curve – The Work of Master Plan Review Consulting Services in K International Airport in West Java

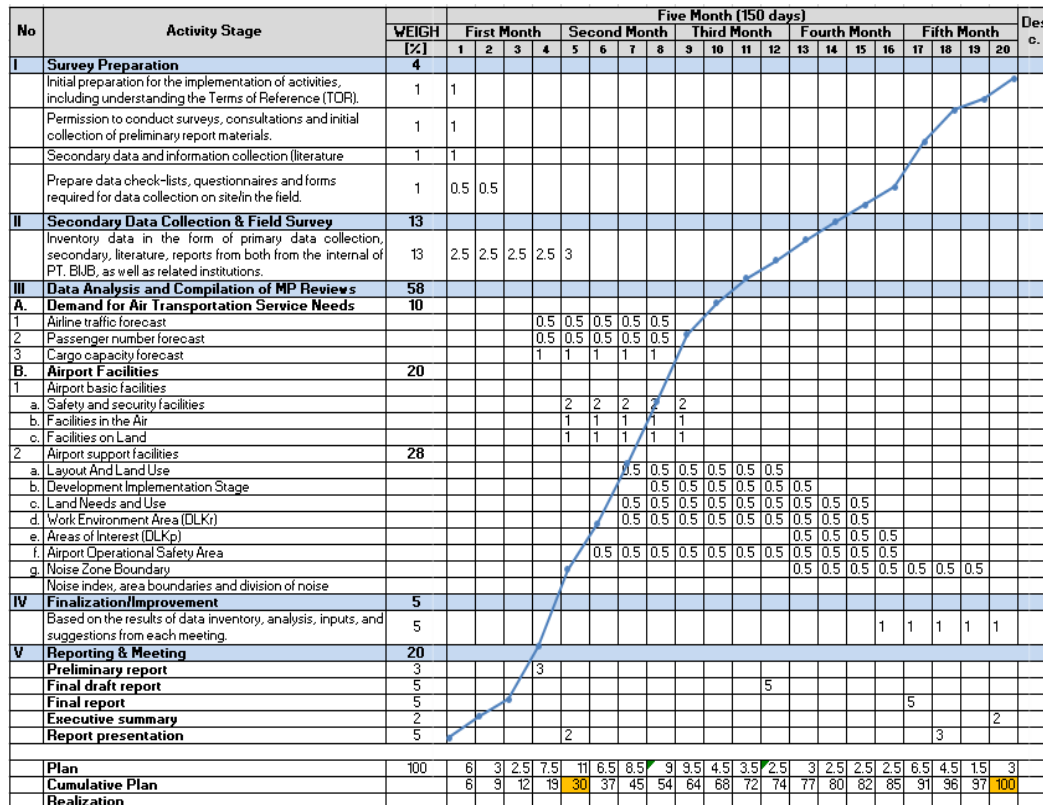


Figure 5. Time Schedule of The S Curve from PT. X

From the S curve, it can be seen that the specific execution time for Preparatory Works, Land and Backfill works, and Structural Works is to be completed in 20 weeks or five months.

Based on the collection of primary and secondary data on the work of master plan review consulting services in K international airport in West Java, there are time schedule data in the form of an S curve and the interview data that have been conducted. Based on them, it can be explained that the conducted work item is the finishing work item data. The interview data used is to determine the predecessors. The completion duration of the work of master plan review consulting services in K international airport in West Java is estimated to be 20 weeks.

The description of the finishing work items, along with the duration of implementation and the relationship between previous activities (predecessor), can be seen in Table 2. Each work item is given an activity symbol to make it easier to create a network diagram. Each floor of the building is coded in the form of an alphabet, while each sub-item of work on the building floor is coded in the form of an alphabet and numbers. Likewise, the predecessor column is given a code that follows the activity symbol. If the work does not have previous activities, it will be marked (-).

Table 2

Job Activity Description

| No | Activity Stage | Activity | WEIGHT {%} | Time Week | Predecessor |
|-----|---|----------|---------------|-----------|---------------|
| 1 | Survey preparation | | 4 | | |
| | Initial preparation for the implementation of activities including understanding the term of reference (TOR) | A | 1 | 1 | - |
| | Permission to conduct surveys consultation and initial collection of preliminary report materials. | B | 1 | 1 | - |
| | Secondary data and information collection (literature study) | C | 1 | 1 | - |
| | Prepare data check list questionnaires and forms required for data collection on site in the field. | D | 1 | 1 | - |
| ii | Secondary data collection and field survey | | 13 | | |
| | Inventory data in the form of primary data Collection, secondary literature reports from both from the internal of PT. BIJB as well as related institution. | E | 13 | 5 | A,B,C,D |
| III | Data analysis | | 58 | | |
| A | Demand for Air transportation Service need | | 10 | | |
| 1 | Airline traffic forecast | F | | 5 | E |
| 2 | Passenger Number Forecast | G | | 5 | E |
| 3 | Cargo capacity Forecast | H | | 5 | E |
| B | Airport facilities | | 20 | | |
| 1 | Airport basic facilities | | | | |
| a | Safety and security facilities | I | | 5 | E |
| b | Facilities in the Air | J | | 5 | E |
| c | Facilities on land | K | | 5 | E |
| 2 | Airport Support Facilities | | 28 | | |
| a | Layout and land use | L | | 6 | E |
| b | Development implementation stage | M | | 6 | E |
| c | Land need and use | N | | 9 | E |
| d | Work environment Area (DLKr) | O | | 9 | E |
| e | Areas of interest (DLKp) | P | | 4 | E |
| f | Airport operational safety Area | Q | | 11 | E |
| g | Noise zone boundary | R | | 6 | E |
| | Noise index area boundaries and Division of noise boundaries | | | | |
| IV | Finalization / Improvements | | 5 | | |
| | Based on results of data inventory analysis input and suggestion from each meeting | S | 5 | 5 | V, W |
| V | Reporting and meeting | | 20 | | |
| | Preliminary report | U | 2 | 1 | E |
| | Preliminary report presentation | V | 2 | 1 | F.G.H.I.J,K,U |

| | | | | |
|---------------------|---|---|---|-------------|
| Final draft report | W | 5 | 1 | L,M,N,O,P,R |
| Executive summary | x | 2 | 1 | S |
| Report presentation | y | 3 | 1 | X |

Working Network Diagram of Time Acceleration

Based on Table 2, the next is to make a network diagram by applying the steps of the Critical Path Method. The calculation of time and critical path in this research was done by first calculating the forward-pass stages for each network. After the calculation, the forward-pass is obtained until the final time, then backward-pass analysis was performed. After all circles were filled with the calculation numbers from forward-pass and backward-pass, the critical path was determined, marked with a red arrow, which can be seen in Figure 6 below.

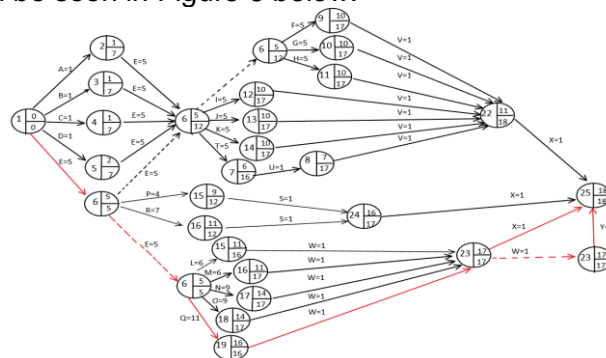


Figure 6. Working Network Diagram of Critical Path Method (CPM)

From Figure 6, Network Diagram, the critical path is marked with a red arrow which can be described in Figure 4.3 below.

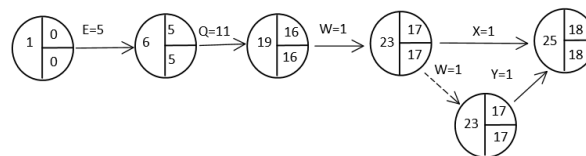


Figure 7. Critical Path

In Figure 7, the slack that occurs on the critical path is zero (0), based on the subtraction between the forward-pass and the backward-pass. The critical path is an activity path that should not experience delays. In Figure 7, the critical path obtained includes **E-Q-W-dummy-Y-X** activities. The activities are described in table 3 below.

Table 3

Activities within the Critical Path

| No | Tahapan kegiatan | Activity | WEIGHT (week) | Predecessor |
|--|---|----------|------------------|-------------|
| Pengumpulan data sekunder and survei lapangan | | | | |
| 1 | Inventarisasi data berupa; pengumpulan data primer, Sekunder, literature, laporan, dan lain sebagainya, baik dari intetrnal PT. BIJB, | E | % | A,B,C,D |

| | | | | |
|---|--|----------|-----------|-------------|
| | maupun instansi Terkait | | | |
| | Analisis Data and penyusunan Review MP | | | |
| 2 | Tata letak Dan Tata Guna Lahan | Q | 11 | E |
| | Pelaporan and pertemuan | | | |
| | Laporan final | W | 1 | L,M,N,O,P,R |
| | Executive summary | X | 1 | S |
| | Presentasi laporan final | y | 1 | X |

Based on this research, the activities or work items that go through the critical path in table 4.2, are work items that should not experience delays in the work of master plan review consulting services in K international airport in West Java because it will affect the final time of project completion. If the work on the critical path or path is delayed, the completion of the project, which should have been 18 weeks, will experience delays.

The work of master plan review consulting services in K International Airport in West Java with the scheduling of the CPM method can be conducted in 18 weeks to complete a series of work activities, with a budget of Rp. 2,818,381,500 from the original plan by the executor of the master plan review consulting services in K International Airport in West Java was 20 weeks with a total budget of Rp. 3.131.535.000. Therefore, there is a budget efficiency of Rp. 313,153,500- and 2-week time efficiency.

Conclusion

From the results of data processing, it can be concluded as follows: items of work that pass through the critical path using the Critical Path Method in consulting services for reviewing the master plan of the K international airport, West Java, include work items for **E-L-R-W-Wdummy- Y-X** activities (in table 4.2.), where the work item must not experience delays because the slack value obtained is 0 (zero). Consultation services for the master plan review of K International Airport in West Java with the scheduling of the CPM method can be conducted in 18 weeks to complete a series of work activities. In addition, it can streamline the budget to Rp. 2,818,381,500 from the original plan by the executor of the master plan review consulting services of K International Airport in West Java, being 20 weeks with a total budget of Rp. 3,131,535,000. Therefore, it is expected that time planning should be conducted in advance to create a good workflow and an estimated completion duration for each work item, taking into account work experience on similar previous projects. It is recommended that this Critical Path Method be carried out before the project starts to anticipate jobs that may experience delays and analyze in advance the factors that can cause delays, both internal and external factors.

Suggestion

This research shows that scheduling with the CPM method can shorten the schedule for implementing activities and make costs efficient in conducting a project. Therefore, this is significantly beneficial in controlling project time and cost efficiency.

Acknowledgment

We would like to express our appreciation to PT X for supporting and assisting us in providing data and information in this research.

References

1. Render, B. and R.M. Staire Jr, *Michael E. Hanna Quantitative Analysis for Management. 8-th edition*. 2003, Pearson Education Inc. p. 432-456.
2. Khan, T., et al., *Statistical analysis and temporal trend of annual maximum temperature with teleconnection patterns of different stations in Pakistan*. Arabian Journal of Geosciences, 2021. **14**(15): p. 1-13.
3. Dyahrini, W., A.R. Syahputra, and N. Nurlita, *Management Analysis of Solar Power Plant Project 409 Kwp (Case Study at PT. Kideco Jaya Agung in Paser District, East Kalimantan Province)*. Psychology and Education Journal, 2021. **58**(1): p. 6335-6342.
4. Arditi, D., O.B. Tokdemir, and K. Suh, *Challenges in line-of-balance scheduling*. Journal of construction engineering and management, 2002. **128**(6): p. 545-556.
5. Al-Jayyousi, G.F., K.S. Myers-Bowman, and F. Al-Salim, *American Muslim Adolescent Daughters' Perception of Maternal Relationships and the Influence on their Health Behaviors: A Conceptual Model*. American Journal of Health Behavior, 2021. **45**(4): p. 642-656 DOI: <https://doi.org/10.5993/AJHB.45.4.4>.
6. Husein, A. and M.P. Perencanaan, *Project Scheduling, and Control (Revised Edition)*. Yogyakarta: Andi Offset, 2011.
7. Herlinda, S., et al., *Metodologi Penelitian*. 2010, Unsri Press. p. 765-786.
8. Hegazy, T. and E. Kamarah, *Efficient repetitive scheduling for high-rise construction*. Journal of construction engineering and management, 2008. **134**(4): p. 253-264 DOI: [https://doi.org/10.1061/\(ASCE\)0733-9364\(2008\)134:4\(253\)](https://doi.org/10.1061/(ASCE)0733-9364(2008)134:4(253)).
9. Hegazy, T. and N. Wassef, *Cost optimization in projects with repetitive nonserial activities*. Journal of Construction Engineering and Management, 2001. **127**(3): p. 183-191 DOI: [https://doi.org/10.1061/\(ASCE\)0733-9364\(2001\)127:3\(183\)](https://doi.org/10.1061/(ASCE)0733-9364(2001)127:3(183)).
10. Alyahya, M.S., et al., *Effect of Multimedia Messaging Service on Exercise Self-efficacy in Diabetic Patients*. American Journal of Health Behavior, 2021. **45**(5): p. 902-915 DOI: <https://doi.org/10.5993/AJHB.45.5.10>.
11. Laksito, B., *Comparative Study of Repetitive Construction Project Scheduling Using Iterative Scheduling Method (RSM) and Precedent Diagram Method (PDM)*. Media Teknik Sipil, 2005. **5**(2): p. 85-92.
12. Baruth, M., et al., *The Association between Weight-related Variables and Postpartum Depressive Symptoms*. American Journal of Health Behavior, 2021. **45**(5): p. 916-923 DOI: <https://doi.org/10.5993/AJHB.45.5.11>.
13. Utomo, C. and R.A. Wibowo, *Design Management Monograph: Sustainability Factors of Bridge Infrastructure Object Project*. Vol. 32. 2020: Deepublish.
14. Setianto, A., *Comparative Study of BarChart Method with Line of Balance in Scheduling Housing Development Activities*. 2004.
15. Tulung, J.M., *Evaluation of Level IV Leadership Education and Training Program at Manado Religious Education and Training Center*. ACTA DIURNA KOMUNIKASI, 2014. **3**(3).
16. Kenley, R. and O. Seppänen. *Location-based management of construction projects: Part of a new typology for project scheduling methodologies*. IEEE DOI: <https://doi.org/10.1109/WSC.2009.5429669>.
17. Lestari, D., *Application of Line of Balance Method in Housing Development (Case Study on Permata Puri Ngaliyan Housing Semarang)*. Jurnal Teknik Sipil, 2018. **9**.
18. Glenwright Jr, E.T., *Let's scrap the precedence diagramming method*. AACE International Transactions, 2004. **21**(8): p. PS81.
19. Coelho, O., et al., *The Arabic Version of the personality inventory for the DSM-5 (PID-5) in a clinical sample of United Arab Emirates (UAE) Nationals*. American journal of health behavior, 2020. **44**(6): p. 794-806 DOI: <https://doi.org/10.5993/AJHB.44.6.5>.
20. Ammar, M.A. and E. Elbeltagi, *Algorithm for determining controlling path considering resource continuity*. Journal of computing in civil engineering, 2001. **15**(4): p. 292-298 DOI: [https://doi.org/10.1061/\(ASCE\)0887-3801\(2001\)15:4\(292\)](https://doi.org/10.1061/(ASCE)0887-3801(2001)15:4(292)).
21. Hassanein, A. and O. Moselhi, *Planning and scheduling highway construction*. Journal of Construction Engineering and Management, 2004. **130**(5): p. 638-646 DOI: [https://doi.org/10.1061/\(ASCE\)0733-9364\(2004\)130:5\(638\)](https://doi.org/10.1061/(ASCE)0733-9364(2004)130:5(638)).