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Optimization of time scheduling planning with the precedence diagram method (PDM) on the drainage construction project

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ABSTRACT

Jalan Pemuda 1 is one of the city roads located in the Samarinda region that often experiences flooding. Therefore, the construction of adequate drainage is necessary to address this flood issue. The construction of this drainage system is expected to effectively solve the flooding problems in the area. The project utilizes precast U-ditches as part of the drainage, replacing the less effective manual methods. The project site frequently experiences tidal fluctuations from the Karangmumus River, which triggers the floods. The U-ditch Precast has dimensions of 240 cm width, 180 cm height, and 10 cm length. Additionally, this research aims to analyze the time optimization in drainage channel construction projects using the Precedence Diagram Method (PDM). The critical tasks in the construction of the drainage channel project are also analyzed using the PDM method. In this research phase, the author chose the Precedence Diagram Method (PDM) not only to clarify the tasks but also to improve project management efficiency and effectiveness to achieve optimal results. The advantage of the Precedence Diagram Method (PDM) is that it does not require dummy or additional activities, simplifies the project network creation, and the interdependence between activities can be arranged without adding new tasks. The accelerated tasks include mobility work, reduced from 7 days to 2 days, and demobilization, reduced from 7 days to 1 day. The occupational safety and health management system (K3) is reduced from 7 days to 2 days, and utility tasks (PDAM, PLN, Telkom) are reduced from 7 days to 2 days. The initial project scheduling indicates a duration of 210 days, but with optimization, the project is completed in 196 days, resulting in a time savings of 13 days. This study provides insights into the effectiveness of the PDM method in addressing critical challenges in construction projects, with implementation leading to more efficient planning and timely project completion

ABSTRAK

Jalan Pemuda 1 merupakan salah satu jalan kota di kawasan Samarinda yang sering mengalami banjir. Sehingga perlu dibangun drainase yang memadai untuk mengatasi banjir. Pembangunan konstruksi drainase ini diharapkan mampu mengatasi permasalahan banjir di kawasan tersebut. Proyek ini memanfaatkan U-ditch pracetak sebagai bagian drainasenya, menggantikan cara manual yang kurang efektif. Lokasi proyek sering mengalami pasang surut air sungai Karangmumus sehingga memicu banjir. U-ditch Precast mempunyai dimensi lebar 240 cm, tinggi 180 cm dan panjang 10 cm. Selain itu penelitian ini juga bertujuan untuk menganalisis optimasi waktu pada proyek pembangunan saluran drainase dengan metode PDM. Untuk menganalisis pekerjaan kritis pada proyek pembangunan saluran drainase dengan menggunakan metode PDM. Pada tahap penelitian ini, penulis memilih Metode Precedence Diagram (PDM) tidak hanya untuk memperjelas pekerjaan, tetapi juga untuk meningkatkan efisiensi dan efektivitas manajemen proyek agar mencapai hasil yang optimal. Kelebihan Metode Precedence Diagram (PDM) adalah tidak memerlukan aktivitas palsu atau tambahan, sehingga pembuatan proyek jaringan menjadi lebih sederhana, dan hubungan tumpang tindih antar aktivitas dapat diatur tanpa perlu menambah aktivitas baru. Jenis pekerjaan yang dipercepat adalah pekerjaan mobilitas dari 7 hari menjadi 2 hari dan demobilisasi dari 7 hari menjadi 1 hari, sistem manajemen K3 dari 7 hari menjadi 2 hari dan pekerjaan utilitas (PDAM, PLN, Telkom) dari 7 hari menjadi 2 hari. Penjadwalan proyek awal menunjukkan durasi 210 hari, namun dengan optimalisasi waktu, proyek selesai dalam 196 hari sehingga menimbulkan selisih waktu tambahan 13 hari. Studi ini memberikan wawasan tentang efektivitas metode PDM dalam mengatasi tantangan konstruksi proyek yang penting, dengan implementasi yang menghasilkan perencanaan yang lebih efisien dan penyelesaian proyek tepat waktu.

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1. Introduction

In the SEMANI (Sentosa-Remaja-A.Yani) flood control drainage work project on Jalan Pemuda 1, precast U-ditch was used as the drainage because the previous one used manual and was less effective, conditions at the project site often had highs and lows in the Karangmumus river which caused flooding. . In this case the drainage is 240 cm wide, 180 cm high and 10 cm long.

Regarding delays in work time, there may be an over budget [1]. To overcome this, it is necessary to optimize work time [2]. These delays are also hampered by administration, project data, owner, material delays [3][4]. What is still lacking is to arrange maximum time scheduling for projects. In an effort to avoid delays in project implementation time, it is very important to carry out research on optimizing delay times and looking for critical work that occurs in youth projects 1.

Facts in the field show that the completion time of a project can vary, making it difficult to ensure that the estimated project completion time will be correct [5]. The level of accuracy of project completion time estimates depends on the extent to which the estimated duration of each activity in the project can be trusted. Apart from time estimation, it is also important to identify critical work and optimize time on the project [6]. Therefore, it is necessary to use the PDM project control method to ensure that the project can be completed and every job is efficien [7]. Project control has a very important role in directing the project process. In this planning stage, the author chose the Precedence Diagram Method (PDM) not only to clarify the work, but also to increase the efficiency and effectiveness of project management in order to achieve optimal results [8] [9]. The advantage of the PDM (Precedence Diagram Method) method is that it does not require fake or additional activities, so creating network projects becomes simpler, and overlapping relationships between activities can be arranged without the need to add new activities [10][11]. ObjectiveThis research is analyzing critical work and optimization in time scheduling using the method*Precedence Diagram Method* (PDM). The limitation of this research problem is optimizing the implementation time for the drainage channel construction project located in Pemuda 1 Samarinda City in the 2023 Fiscal Year using the PDM method.

2. Research methods

2.1 Research Flow Chart

The process stages that will be carried out in this research begins with determining the location to be researched, followed by collecting relevant journals, books and literature related to project scheduling. Next, look for and use secondary data and primary data, such as project time schedules, obtained from the project owner. Data processing is carried out using the PDM method. The results and discussions of this phase address the project's critical path and project time optimization. Conclusions and recommendations are based on the steps that have been taken, as well as the results and analysis that have been presented.

2.2 Research procedure

The research stage is a way of working to understandresearch steps which are the research objectives to obtain the best results. The study is for the construction of a 300 meter long drainage channel on Jalan Pemuda 1 in the Semani neighborhood (Sentosa-Remaja-Ahamd Yani) Samarinda City.

2.2.1 PDM dependency logic relationships

The PDM method is a project planning method that uses Activity on Node (AON) and is represented in a rectangular shape, with arrows as indicators of the relationship between activities. In contrast to CPM and PERT which use a dummy to show dependency, the PDM method does not require the use of a dummy [12][13][14]. The explanation in the PDM Method includes aspects of overlapping activities, precedence diagram structure, constraints, and identification of the critical path used in PDM calculations. The success of the critical path in project implementation is also emphasized, as activities on this path can have a significant impact on the overall delay of the project if implementation is delayed [15][16]. In the PDM method there are also what are known as constraints. A constraint can only connect two nodes, because each node has two points, namely the starting point (S) and the ending point (F) [17]. Therefore, there are four types of constraints here:

a. Constraints from finish to start (FS)

The concept of constraints in PDM, the formula is (ij)=a, which means activity (i) must be completed before activity (j) can be implemented. In projects the desired value of a is usually 0 [18], it can be seen in Figure 1.

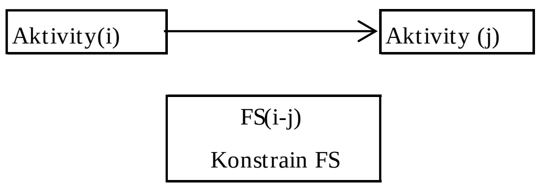


Figure 1. Finish to start

b. Start – start (SS) constraint

This concept explanation describes the relationship between the start of an activity and the start of previous activities in PDM. An example is SS(ij)=b, which means that activity (j) starts b days after the start of the previous activity (i) [7]. This type of constraint occurs if activity (j) can be started after activity (i) has started, provided that the previous activity (i) has not been completely completed (100%) [19]. The b value must not exceed the duration of the previous activity, so that there is a buildup in implementation (Figure 2).

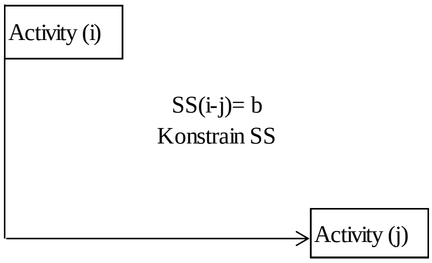


Figure 2. Start to start

c. Finish to Finish (FF) Constraint

The formula is FF(ij)=c, which means activity (j) will be completed after c days from the completion of the previous activity (i). This type of constraint ensures that activity (j) does not reach 100% completion before the previous activity (i) has been completed for c days [1][20]. The value of c cannot exceed the duration of the activity (j) itself (Figure 3).

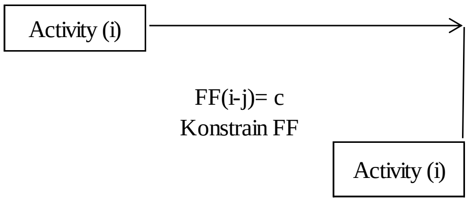


Figure 3. Finish to finish

d. Start to finish constraints

The formula is SF(ij)=d, which means activity (j) is completed after d days since the previous activity (i) started. This indicates that some part of the previous activity must have been started before the last part of the activity currently being completed can be completed [21], it can be seen in Figure 4.

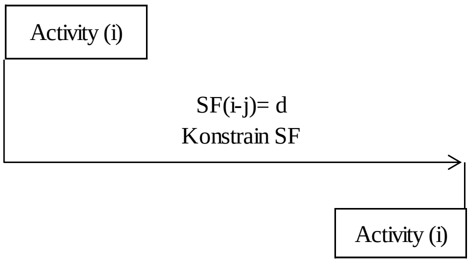


Figure 4.Start to finish constraints

2.2.2 PDM Calculation Technique and Critical Path

Calculations in the PDM Method involve the steps of identifying and assessing the duration of activities, as well as determining links or dependencies between activities [22]. Project managers use time estimation data to establish the optimal duration of each activity. The PDM method is included in the Activity on Node (AON) category in the form of a working network [23]. Activities are represented by rectangular nodes, while arrows are used to show connections between activities [24]. Symbols are easy to identify, supporting clear visual representation in project planning [7].

<table>
<tr><td>ICE</td><td colspan="2" rowspan="2">TYPE
ACTIVITY</td><td>E.F</td></tr>
<tr><td>L.S</td><td>LF</td></tr>
<tr><td colspan="2">ACTIVITY NO</td><td colspan="2">DURATION</td></tr>
</table>

Figure 5. Symbol of PDM activities

The PDM method is a planning technique in project management that uses link diagrams to illustrate dependencies between tasks or activities in a project [9]. In this context, the term "critical path" refers to the sequence of activities that takes the longest total time to complete [25].

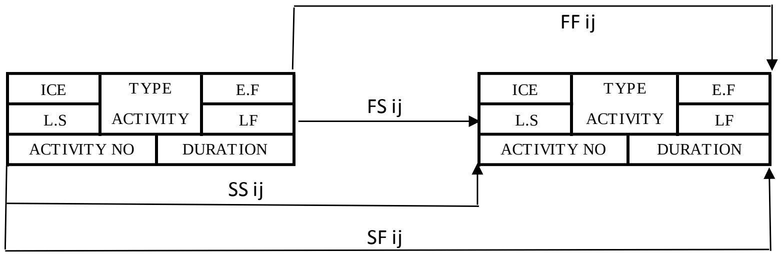


Figure 6. Activity (i) and (j)

2.2.3 Time delay analysis (float), Time/schedule, Workforce Planning, and Duration

Time delay analysis, otherwise known as float, refers to the duration of time available on an activity, providing the possibility for delays or slowdowns, whether intentional or not. Schedule or duration in the PDM Method refers to determining the time needed to complete each activity in a project. In the PDM Method, each activity is represented as a node in a diagram, and the duration of each activity becomes a key element in project schedule planning [26]. Network planning is a project organizing model that produces information about activities in the form of a network diagram of related projects [27][28]. This network plan is a visual representation of the activities required to achieve the final goal.

Duration in the PDM Method refers to the amount of time required to complete each activity in a project. Within the framework of this method, each activity is represented as a node in a diagram, and the length of time required to carry out each activity becomes a key factor in determining the critical path and total project duration. A good understanding of the duration of each activity is crucial in the PDM method because it enables project managers to make informed and realistic decisions in planning and executing the project effectively.

Scheduling is a detailed plan of the project that systematically arranges steps to achieve maximum goals. Some important aspects to consider when preparing a project schedule are:

a. Including all activities comprehensively, identifying various types of activities along with their sequences and time estimates. This means no part of the work should be overlooked.
b. Integrating with other planning elements, such as the budget, to form a scheduled budget.
c. The schedule must be comprehensive yet not overly complicated, and easily understood by all relevant parties. Therefore, the schedule must be tailored to its purpose.

3. Results and Discussion

3.1 Project Data Observation and Job Description

Construction work of continued drainage for flood control at SEMANI (Sentosa-Remaja-A.Yani) on Jalan Pemuda 1 Samarinda City is financially supported by (APBD) Samarinda City 2023. This drainage construction project is located on Jalan Pemuda 1 with a drainage channel length of 300 meters. The end of this drainage channel passes into the Karangmumus River. This project contract has a value of Rp. 4,141,000,000 (Four Billion One Hundred Forty One Million). The contractor appointed to carry out this project is CV. Gading Kencono Emas, as agreed in contract number: 602/Bid-SDA/PPKom/590/VI/2023 which was stipulated on 05 June 2023.

With information provided by the CV contractor. Gading Kencono Emas, the data required for this research has been obtained in the form of a time schedule. Furthermore, the data collected in this study will be analyzed further in the context of project planning using network planning techniques, namely the PDM method.

Figure 7. Project location

In this research, there are 9 types of work carried out on the project, namely: K3 management system work, Utilities (PDAM, PLN, Telkom), Mobilization & Demobilization, Excavated soil is thrown away (tools), Dismantling of concrete, Disassembly of stone, Loose wood, Galam wood stake with base 12-15 cm, L= 3.75 m (mechanical), Reinforcing, PVC Pipe Pair 3, Formwork, Concrete K-250, Soil embankment (mechanical).

3.2 PDM Method Network Analysis

In this section, data analysis aims to identify critical paths and time optimization in the processconstruction of continued drainage for flood control SEMANI (Sentosa-Remaja-A.Yani) on Jalan Pemuda 1 Samarinda City, will it run according to the time schedule that has been prepared by the contractor implementing accelerated research and development using the PDM method.

3.2.1 Scheduling analysis according to time schedule

The results of the scheduling analysis according to the time schedule using the PDM approach can be seen in Table 1 below.

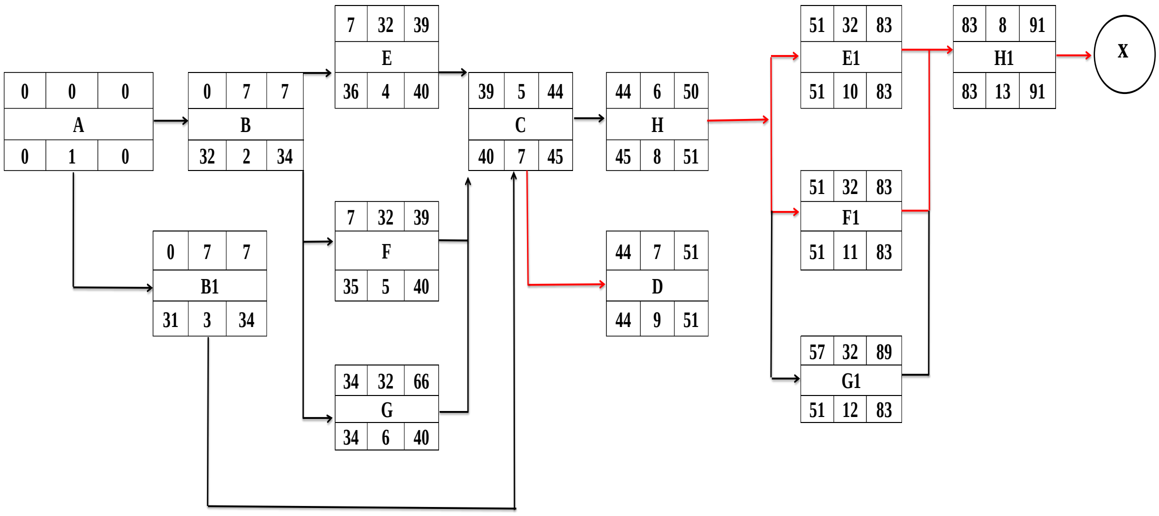
Table 1. Scheduling Analysis According to Time Schedule

No	Activity	Code	Day	Predecessor Activities	Next Activity	Constraints
1	Start Activity	A	0	-	B	F.S
2	K3 Management System work week 1	B	7	A	E, F, G	F.S
	Utilities (PDAM, PLN, TELKOM) week 1	B1	7	B	C	F.S
3	Mobilization week 8	C	7	E, F, G, B1	H, D	F.S
4	Soil Excavation Discarded (Tools) weeks 9, 14, 19, 24	D=9	7,7,7,7	C	E1, F1, G1	F.S
	Concrete removal weeks 9, 14,19, 24	D1=14		H	H1	F.S
	Unloading stone fitting week 9,14,19,24	D2=19		E1, F1, G1	D1	F.S
	Unloading week 9,14,19,24	D3=24		H1	E2, F2, G2	F.S
	Galam wooden stake at base 12-15 cm, L= 3.75 m (mechanical) weeks 9, 14, 19.24			D1	H2	F.S
5	Refinement weeks 5 & 8, 10 & 13, 15 & 18, 20 & 23	E=5-8 E1=10-13 E2=15-18 E3=20-23	32	E2, F2, G2	D2	F.S
6	Pair of PVC Pipes 3 weeks 5 & 8, 10 & 13, 15 & 18, 20 & 23	F=5-8 F1=10-13 F2=15-18 F3=20-23		H2	E3, F3, G3	F.S
7	Formwork weeks 5 & 8, 10 &13, 15 & 18, 20 & 23	G=5-8 G1=10-13 G2=15-18 G3=20-23		D2	H3	F.S
8	Concrete K-250 weeks 5 & 8, 10 & 13, 15 & 18, 20 & 23	H=5-8 H1=10-13 H2=15-18 H3=20-23		E3, F3, G3	D3	F.S
9	Soil stockpiling (mechanical) week 25	I	11	H3	I	F.S
10	Demobility week 28	J	4	D3	J	F.S

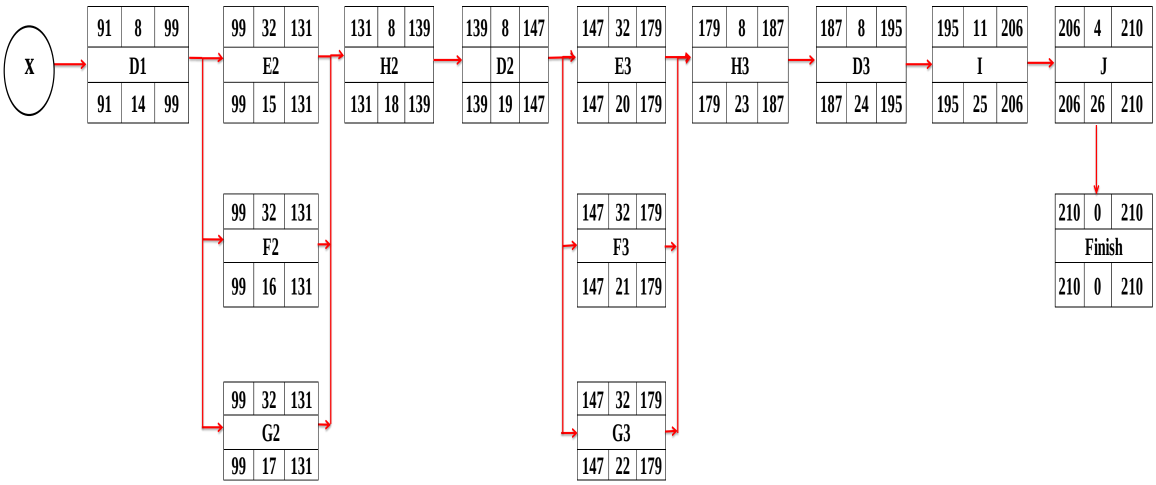
The results of network optimization using the PDM approach are a time schedule that describes the description of the work or activity in progress, the activity code, and the activity that precedes it (predecessor), the activity that follows it (successor), and the duration of the activity. Starting the first week's activities with code B with K3 and Utilities management system work (PDAM, PLN, and TELKOM) duration 7 days per week, preliminary activities (-), with a logical count of FS (finished - started) with a Lead/lag value of 0. After that Subsequent work activities in weeks 5 and 8 have codes E, F, G with a duration of 32 days, previous activities have code A with a duration of 0 days. The next activity was in week 8 with a duration of 8 days with code C, the next activity in weeks 5 & 8 with code H had a duration of 32 days with the work "K-250 concrete", along with week 9 with the previous activity having code D with duration 7 days.

After that, the next work activity in weeks 10 and 15 has codes E1, F1, G1 with a duration of 32 days, the previous activity has code H with a duration of 32 days. The next activity with code H1 has a duration of 32 days with the work "K-250 concrete", after that the previous activity has codes E1, F1, G1 with a duration of 32 days. After that, the next activity with code D1 has a duration of 7 days, with previous work with code H1. After that, the next work activity in weeks 15 and 18 has codes E2, F2, G2 with a duration of 32 days, the previous activity has code D1 with a duration of 7 days. The next activity with code H2 has a duration of 32 days with the work "K-250 concrete", after that the previous activity has codes E2, F2, G2 with a duration of 32 days. After that, the next activity with code D2 has a duration of 7 days, with previous work with code H2.

After that, the next work activity in weeks 20 and 23 has codes E2, F3, G3 with a duration of 32 days, the previous activity has code D2 with a duration of 7 days. The next activity with code H3 has a duration of 32 days with "K-250 concrete" work, after that the previous activity has codes E2, F3, G3 with a duration of 7 days. After that, the next activity with code D3 has a duration of 7 days. After that, the previous activity has code H3 with a duration of 32 days, with the next activity having code I with earth filling work (mechanical) in week 25 having a duration of 11 days. After that the previous activity with code D3has a duration of 7 days. After that, the next activity is Demobility work with code J. Describes the network form of the PDM method which contains information about the job description or current job, code, activity duration, preliminary activities, subsequent activities, and constraints.



(a)



(b)

Figure 8. Work network diagram according to time schedule (a) starting from work activities to K250 concrete and (b) earth excavation, concrete demolition, wood demolition, galam wood stakes with code D1 to finish using the PDM method.

3.2.2 Accelerated Scheduling Analysis Using the PDM Method

The results of the evaluation of accelerated scheduling using the PDM approach can be seen in Table 2.

Table 2 Accelerated Scheduling Analysis using the PDM method

No	Activity	Code	Day	Predecessor Activities	Next Activity	Constraints
1	K3 Management System Work Utilities (PDAM, PLN, TELKOM)	A	2	-	B	-
2	Mobilization	B	2	A	C	-
3	Disposable Soil Excavation (Tools)	C	42	B	D, E, F	FS(2-10)=0
	Dismantling of concrete			B	D, E, F	FS(2-11)=0
	Disassembly of stone			B	D, E, F	FS(2-12)=0
	Loose wood			B	D, E, F	FS(2-4)=0

No	Activity	Code	Day	Predecessor Activities	Next Activity	Constraints
	Galam wood stake with base 12-15 cm, L= 3.75 m (mechanical)			C	G	FS(10-3)=0 FS(11-3)=0 FS(12-3)= 0
8	Reinforcing	D	130	D, E, F	G	FS=(4-9)=0
9	PVC Pipe Pair 3	E	130	D, E, F	G	FS=(5-9)=0
10	Formwork	F	130	D, E, F	G	FS=(6-9)=0
11	Concrete K-250	G	130	D, E, F	H	FS=(112)=0
12	Soil embankment (mechanical)	H	11	G	I	FS=(3-9)=2
13	Demobility	I	1	H	-	FS=(3-9)=2

In this accelerated scheduling, some activities that are carried out simultaneously are combined, such as activities with code A and have a duration of 2 days. Work on the K3 management system which is very important in a project, which can also be carried out by several project members to carry out K3 activities in time. 2 days, so that other project members don't have to do just enough representation. And the activity that goes hand in hand with K3 management is Utility work (PDAM, PLN, TELKOM) because it is important to get permission from local parties so that the project runs smoothly, this work is also sufficient for representatives not to need all members, so that other members can prepare for further work.

The results of network analysis using the PDM method are the acceleration of detailed job or activity description methods, including codes, previous activities (predecessors), next activities (substitutes), and the estimated duration of each activity. In the initial activity with code A with a total duration of 2 days without any predecessor activity, without a logical/contraint relationship there is no lead/lag value, which can be seen in Table 2 which is already listed.

The next work is "Reinforcement, Installation of PVC pipe 3, Formwork" with codes D, E, F which has a duration of 130 days with a logical relationship/constraint FS (finished - started) and a lead/lag value of 0. Then in the 11th activity, namely the activity "casting (K-250 concrete)"with code G having a duration of 24 days, the predecessor activitynamely activities with codes D,E,F or activities "Reinforcement, Installation of PVC pipe 3, Formwork" with a logical relationship/constraint FS (Finish to Start) and Lead/Lag value 0. After that, the previous activity with code G has a duration of 130 days and the next activity is mechanical earth filling work with code H which has a duration of 11 days with a logical/constraint relationship FS (Finish to Start) and Lead/Lag value 0. After that, the final job is demobilization work with code I, which has a duration of 1 day.

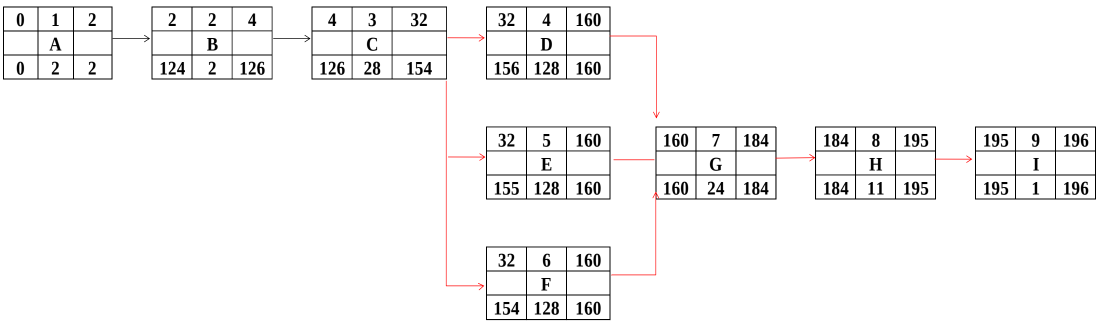


Figure 9. Acceleration Diagram Using PDM Method

3.2.3 Results of PDM Method Analysis with Time Schedule and Acceleration

Analysis of non-critical work paths, namely with codes A, B, B1, C, E, F, G, H, G1. The critical work is D, D1, D2, D3, E1, E2. E3, F1, F2, F3, G2, G3, H1, H2, H3, I, J. With a total project processing time of 210 days. Meanwhile, non-critical actions are A, B, C. Meanwhile, critical work is coded D, E, F, G, H, I. With a total work duration of 196 days with an acceleration of 14 days.

After analyzing and carrying out forward and backward calculations using the PDM method. From the results of this acceleration analysis, it was found that there were four work activities that were accelerated to produce the following optimal activities:

- Mobility from the initial planning of 7 days became 2 days because there was a waste of time, whereas mobility can be done in 1 day or 2 days.
- Demobilization from 7 days to 1 day demobilization work does not take long to carry out mechanical transportation.
- Work on the K3 management system from 7 days to 2 days because K3 work requires quite short instructions, therefore only 2 days.
- Meanwhile for utilities (PDAM, PLN, Telkom) from 7 days to 2 days because the processing of letters can be done at one time.

Determination of the critical path Therefore, critical work in this project includes other actions or nodes such as code D with concrete work, code E with PVC pipe pairing work 3, code F with formwork work, code G with concrete work K-250, code H with earth filling work (mechanized), code I with demobility work. Meanwhile, non-critical actions A, B, C with a total work duration of 196 days with an acceleration of 14 days. This analysis provides an overview of the sequence and relationship between activities in the project, identifies critical paths, as well as an understanding of the duration and dependencies between activities in accelerated project scheduling.

4. Conclusion

With four logical relationships or constraints operating in schedule analysis, the PDM method. Shows a duration of 210 days, but with optimization time the project is completed in 196 days, resulting in an acceleration time difference of 14 days. In four work activities that were accelerated to produce optimal activities mobility from 7 days to 2 days and demobility from 7 days to 1 day, K3 management system work from 7 days to 2 days, while utilities (PDAM, PLN, Telkom) from 7 days became 2 days. By evaluating delays in the SEMANI (Sentosa-Remaja-A.Yani) flood control drainage project using the PDM method, it is expected to assist stakeholders in focusing on critical work types, such as code D for rebar work, code E for PVC pipe installation, code F for formwork, code G for K-250 concrete work, code H for mechanical soil embankment, and code I for demobilization work. This research can be applied to any project experiencing delays or used to redesign the project time schedule.

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