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Analysis of Delay in Secant Pile Foundation Work on the Semantok Dam Project

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***Abstract*—This study aims to find out what factors are the dominant factors causing delays and what improvements need to be made to catch up on delays in the work of the Semantok dam foundation. This study also calculates the time and cost of the secant pile foundation work if crashing is carried out because there is a planning gap in the realization of the secant pile foundation work from February to May 2021 which is quite large. This study uses the calculation method Critical Path Method (CPM), Fishbone Diagram, Root Cause (Why –Why), Project crashing. This research is quantitative descriptive. The results showed that the normal cost of secant pile foundation work at the Semantok Dam with a deviation of Rp.517,830,290 is more expensive to do crashing. Meanwhile, the normal time for secant pile foundation work at the Semantok Dam is 458 days shorter by crashing. The dominant factors causing delays in the secant pile foundation work at the Semantok dam are the Man, Warehouse, Machine factors, where corrective actions that must be carried out are Carrying out refreshment training for operators and technicians, making an action plan for the number of workers needed and conducting workforce recruitment, making action plan plotting a mature work implementation area, carrying out routine maintenance every month, procuring and replacing damaged spare parts, making realistic plans and adding sets of drill tools.**

***Index Terms*—CPM-Crashing, fishbone diagram, why-why analisis**

I. Introduction

The foundation is a very important part of a structure, including water structures such as dams. The purpose of the dam foundation is that the soil stress that arises as a result of the dam's own weight, water pressure, earthquake forces, and loads that work does not exceed the carrying capacity of the dam foundation soil at the bottom or on the left and right banks of the dam.

However, in the foundation work at the Semantok dam, there is a gap between the plan and the realization.PT. PT. Brantas Abipraya (Persero) on the Semantok Dam project in completing a project must be followed up immediately to avoid the same case in future projects. Project delays must be resolved immediately by finding the root cause of the problem..

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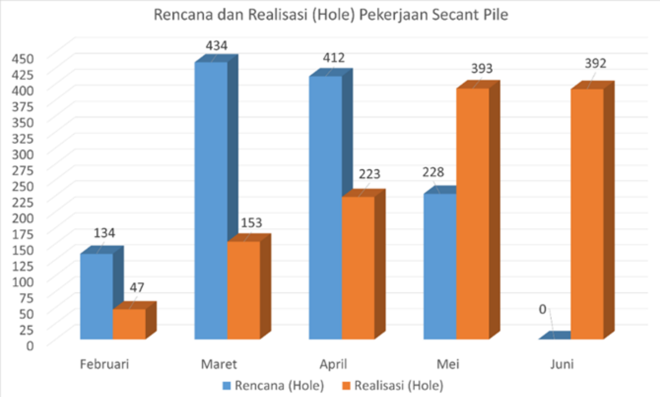

Fig 1:- Rencana dan Realisasi (Hole) Pekerjaan Secant Pile
Source : PT Brantas Abipraya (2022)

By knowing the root causes of the delay, it is possible for the company to evaluate and anticipate what things are causing the problem of delays so that these things don't happen again in the next project..

II. Literature Review

A. *Critical Path Method (CPM)*

According to Heizer & Render (2011: 95) CPM is a project management technique that uses only one time factor per activity. This means that a CPM network consists of branches and nodes representing activities or a project or operation and nodes representing the beginning and end of an activity, referred to as events. The critical path method (CPM) is a project scheduling method that is well known and is often used as a management tool in the implementation of a project. In a CPM schedule consists of several types of activities that are interrelated with one another. If there is a delay in one of the activities, it will have an impact on the overall delay in the duration of the project.

B. *Fishbone Diagram*

It is called a fishbone diagram because this diagram resembles the skeleton of a fish whose parts include the head, fins and spines. The problem that occurs is considered the head of the fish while the cause of the problem is symbolized by fish bones that are connected to the head of the fish. The smallest bones are the most specific causes that build larger causes (larger bones) (Dharmawan, 2016).

C. *Root Cause (Why –Why)*

Why-Why analysis is used to explore the root of the problem to find the right solution to fix it.

D. *Project crashing*

Project crashing is a reduction in activity time in the network to reduce time on the critical path so that the overall project completion time can be reduced (Achmad H & Rosalendro, 2016). To further analyze the relationship between costs and the time of an activity, several terms are used, namely, normal duration, crash duration, normal costs, and crash cost.

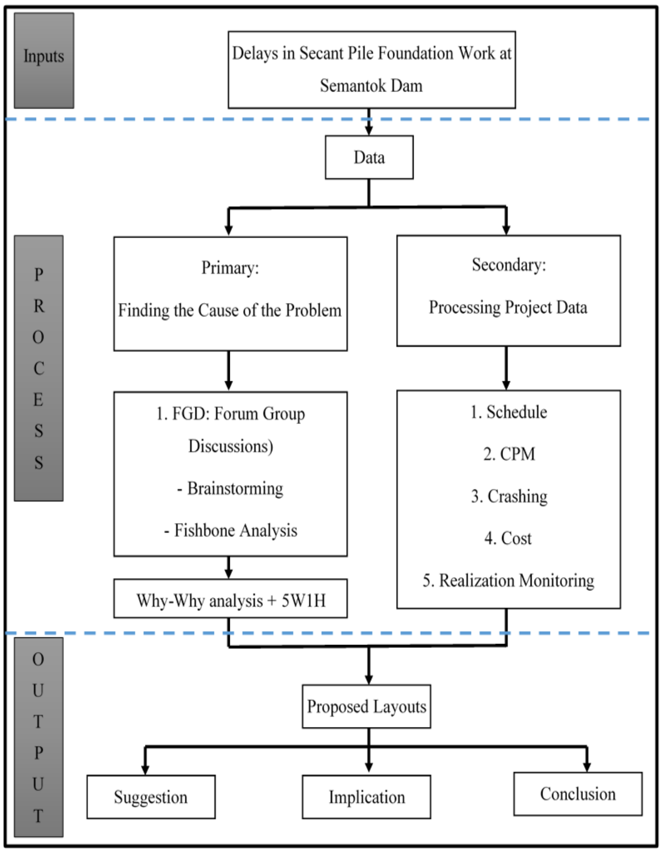

Fig 2:- Thinking Framework
Source : Author (2022)

III. MATHODOLOGY

The research begins with formulating the problem and research title which is supported by a literature review. After that, the research concepts and hypotheses were determined which became the basis for choosing the right research method. To find out the understanding and identify the implementation of scheduling based on the CPM method for the Semantok Dam project, the researcher used project data such as the project schedule and s curve, then the normal time and normal cost of secant pile implementation were known, then crashing was carried out to find out the crashing time and crasing cost. From the data obtained proposed layout, to find out the problems causing delays by conducting interviews with project leaders such as Project Manager, Site Operation Manager, Site Engineering Manager, Site Administration Manager, Site Manager, and staf in the field with the method Brainstorming FGD..

The collected data was analyzed using fishbone and 5W+1H. Furthermore, a discussion of these findings is carried out to find out the causes of the delay in the work of the secant pile foundation at the Semantok Dam. From the results of this analysis it is known that steps for improvement, implications, conclusions, and suggestions for secant pile work in the Semantok Dam.

IV. RESULTS AND DISCUSSION

The following is a description and duration of the secant pile foundation work on the symbol A – B – C – D – E – F – G – H – I – J – K – L – M.

Table 1:- Job Description and Duration

Symbol	Job description	Predecessors	Job Duration (Days)
A	Field Preparation		7
B	Making Guide Wall / Director	A	75
C	Halang Trench Sta.0+000 to 0+9	B	75
D	Secant Pile Drilling	B	105
E	Verticality Test	C,D	105
F	Geological investigation	E	105
G	Oscillator Installation	F	105
H	Tremi installation	G	105
I	Gutter Installation	G	100
J	Plastis concrete casting	H,I	105
K	Capping Enhancement	J	120
L	Capping Concrete	K	80
M	Curing Concrete	L	0

Source : Author (2023)

The following is a forward and backward calculation to determine the critical path as attached

Table 2:- Calculation of forward and backward critical path

Symbol	Job Duration (Days)	Forward Trajectory		Reverse Trajectory		Total Float	On Critical Path
		ES (Earliest Start)	EF (Earliest Finish)	LS (Latest Start)	LF (Latest Finish)		
A	7	0	7	0	7	-	Yes
B	75	7	82	7	82	-	Yes
C	75	82	157	112	187	30	No
D	105	82	187	82	187	-	Yes
E	105	187	292	187	292	-	Yes
F	105	292	397	292	397	-	Yes
G	105	397	502	397	502	-	Yes
H	105	502	607	502	607	-	Yes
I	100	502	602	507	607	5	No
J	105	607	712	607	712	-	Yes
K	120	712	832	712	832	-	Yes
L	80	832	912	832	912	-	Yes
M	0	912	912	912	912	-	Yes

Source : Author (2023)

Based on table above, jobs that are on the critical path are jobs that have a float value = 0, namely A – B – D – E – F – G – H – J – K – L – M jobs. from these data the network and its critical path can be described in the figure below:

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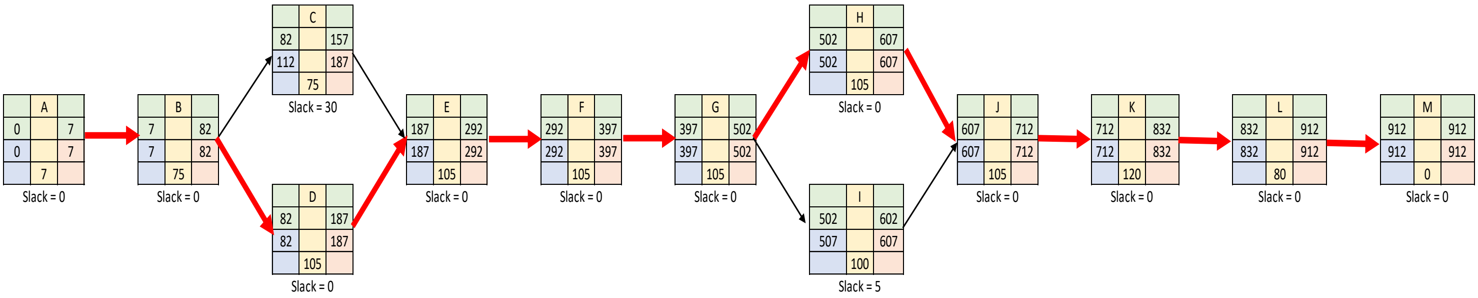

Fig 3:- Network and Critical Path of Secant Pile Work
Source : Author (2023)

1. Normal Time and Crashing Time
   Based on the work network and the critical path of the secant pile work, then calculate the crash time with an alternative addition of labor as shown in the following table:

Table 3:- Normal Time and Crashing Time

Symbol	Job description	Predecessors	Sat	Job volume	Job Duration (Days)	Total Manpower is normal	Normal Productivity per Day	Expected Crash Duration	Add manpower	Crashing Productivity	Real Crash Duration
1	2	3	4	5	6	7	8=5/6	9	10	11=(8*(7+10))/7	12=5/11
A	Field Preparation		ls	1	7	5	0.1	5	5	0.3	4
B	Making Guide Wall / Director	A	m	775	75	20	10.3	40	10	15.5	50
D	Secant Pile Drilling	B	Bh	1208	105	10	11.5	70	10	23.0	53
E	Verticality Test	C,D	Bh	1208	105	20	11.5	70	3	13.2	91
F	Geological investigation	E	m	825	105	20	7.9	70	5	9.8	84
G	Oscillator Installation	F	Bh	1208	105	20	11.5	70	5	14.4	84
H	Tremi installation	G	Bh	1208	105	20	11.5	70	5	14.4	84
J	Plastic concrete casting	H,I	m3	2713.5	105	20	25.8	70	5	32.3	84
K	Capping Enhancement	J	Ton	546	120	20	4.6	75	10	6.8	80
L	Capping Concrete	K	m3	13557.19	80	40	169.5	80	10	211.8	64
					912						677

Source : Author (2022)

Based on the table above, it can be seen that for each work item there is a reduction in duration from the real duration in the field and then crashing is carried out with an alternative addition to the workforce.
The total duration of real work in the field is 912 days, while the duration after crashing with the addition of labor is 667 days, as a result of the crashing there is a reduction in work duration of 235 days from the real duration.

2. Normal Cost and Crashing Cost
   After knowing the normal duration and crashing duration, the next step is to calculate the normal cost and crashing cost. Calculations as shown in the following table.

Table 4:- Normal Cost and Crashing Cost

Symbol	Job description	Job Duration (Days)	Total Manpower is normal	Add manpower	Crash Duration	Additional Wages	Direct Cost (Ticket)	Normal Cost	Crash Cost	Cost Slopes
1	2	3	4	5	6	7	8	9	10=9+(7x6)+8	11=(10-9)/(3-6)
A	Field Preparation	7	5	2	5	260,000.00	1,040,000.00	1,050,000,000.00	1,051,300,000.00	650,000.00
B	Making Guide Wall / Director	75	20	5	60	550,000.00	2,600,000.00	340,068,250.00	375,668,250.00	2,373,333.33
D	Secant Pile Drilling	105	10	10	53	1,500,000.00	5,200,000.00	45,771,631,840.00	45,855,581,840.00	1,599,047.62
E	Verticality Test	105	20	3	91	450,000.00	1,560,000.00	173,985,900.00	216,632,856.52	3,113,904.76
F	Geological investigation	105	20	5	84	1,000,000.00	2,600,000.00	120,000,000.00	206,600,000.00	4,123,809.52
G	Oscillator Installation	105	20	5	84	750,000.00	2,600,000.00	96,000,000.00	161,600,000.00	3,123,809.52
H	Tremi installation	105	20	5	84	500,000.00	2,600,000.00	90,000,000.00	134,600,000.00	2,123,809.52
J	Plastic concrete casting	105	20	5	84	550,000.00	2,600,000.00	19,103,379,333.40	19,152,179,333.40	2,323,809.52
K	Capping Enhancement	120	20	5	96	550,000.00	2,600,000.00	12,869,317,708.35	12,924,717,708.35	2,308,333.33
L	Capping Concrete	80	40	5	71	750,000.00	2,600,000.00	18,902,847,034.37	18,956,180,367.70	6,000,000.00
								98,517,230,066.11	99,035,060,355.97	

Source : Author (2022)

Based on the crashing calculation table above, it is known that the normal cost of secantpile work is Rp. 98,517,230,066.11 due to the acceleration with the addition of labor resulting in an increase in project costs. With a reduced working time of 235 days the project cost increases to Rp. 99,035,060,355.97..

From the results of the above analysis the comparison of normal time and normal cost as well as crashing time and crashing cost on secant pile foundation work can be seen in the table below:

Table 5:- Time Analysis Results, Normal and Crashing Costs

No	Description	Normal	Crashing	Deviation
1	Time (Days)	912	677	235
2	Cost (Rp.)	Rp 98,517,230,066	Rp 99,035,060,356	-Rp 517,830,290

3. *Secant Pile Work Delay Analysis*

This data collection was carried out by measuring direct observations in the field and by interviewing relevant stakeholders..

A. *Focus Group Discussion (FGD)*

In digging deeper into the problems that occur, information/opinion of each worker is needed and trying to discuss the best solution, an open discussion is held between the team, as follows:

Fig 4:- FGD with the Project Leader
Source : Author (2022)

Fig 5:- Site Visit at Bendungan Semantok
Source : Author (2022)

In completing the problem analysis the author held a Focus group discussion (FGD) which was carried out directly with the project team such as the Project Manager, Site Operation Manager, Site Engineering Manager, Site Administration Manager, Site Manager and staff. This aims to seek information directly from the project team by asking a number of questions related to the secant pile foundation work process in the field, asking about the obstacles encountered in implementing the secant pile foundation work process in the field. Discussing the factors that cause problems, starting from general matters to details to the root of the problem. Discuss things that might need to be fixed to reduce ongoing problems. The FGD results were then summarized using a Fishbone Diagram.

B. Analisa Fishbone Diagram (Brainstorming)

Based on the interviews obtained as well as the results of field observations and direct discussions with informants from the Project Manager, Site Operation Manager, Site Engineering Manager, Site Administration Manager, Site Manager, and staff, the parameter factors that influence the occurrence of these losses are taken, namely:
1.Man (Human/Operator/technical personnel/daily workers)
2.Warehouse (Material arrangement, drilling location, site plan)
3. Machine (Accessories, drilling tools)

Of the 3 main factors causing delays in the secant pile foundation work above, the researchers explored information to find out the causes and reasons. The results of the interviews are summarized in the following Fishbone Diagram

From the Fishbone Diagram analysis, the results of the FGD discussion in the Brainstorming process found the main causes by writing down the causes that might occur in groups of main causes. Then the sub-causes in the main cause group are selected which have the most significant effect on the delay in the secant pile foundation work as follows:
1. Man : - Lack of competency of operators and technicians
- Limited amount of daily power
2. Warehouse: - There is a buildup of materials and tools in one place
3. Machine : - Drill tools are often damaged
- Not having sufficient stock of spare parts and drill accessories
- Less drill tools

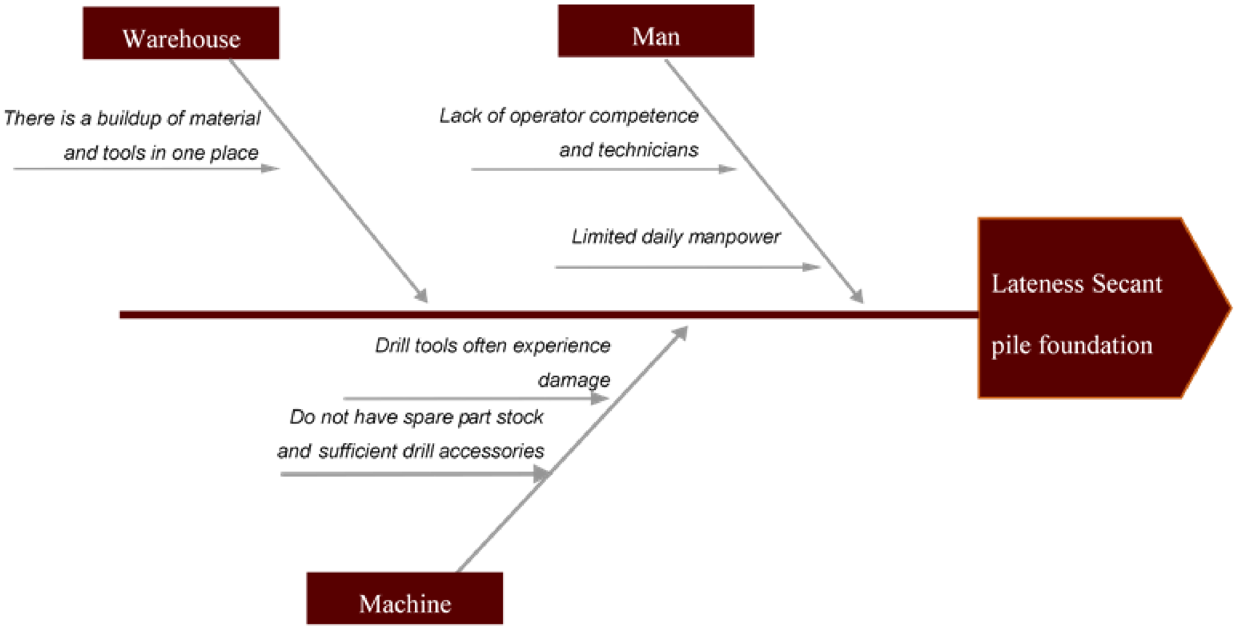

Fig 6:- Fish Bone Diagram
Source : Processed Interview Data (2022)

Furthermore, these significant causes are analyzed further to find the root cause of the problem in each existing loss by asking 5 times a technique called Five Whys or 5 Whys to find out the main cause. As attached in the following table:

Table 5:- Why-Why Analysis

Problem		Why 1	Why 2	Why 3	Why 4	Why 5	Corrective action	Preventive measure
Man :	Lack of competence of operators and technicians	Minimum skills and experience in the Dam	The qualifications of equipment operators and technicians are not appropriate to the field	There is no Refreshment Training for Operators and Technicians				**what:** Refreshment Training Operators and technicians **where:** Operations and Equipment Section **when:** once a year **who:** Site Administration Manager & HC **How:** Carry out Refreshment Training for Operators and technicians
	Limited amount of daily power	Not yet done hiring competent workers	Lack of workforce planning	Financial cashflow is not good			Conduct regular HR recruitment	**what:** Create a workforce action plan & Recruitment of workforce **where:** At every secant pile location **when:** Periodically **who:** Site Administration Manager & HC **How:** Make an action plan for the number of workers needed & carry out recruitment of workers
Warehouse :	There was a buildup of materials and tools in one place	The drilled secantpile foundation is not old enough	The layout of drill tools and materials is random	Lack of planning and work site action plans			Opening new land for drilling locations to prevent accumulation	**what:** Work area plotting planning **where:** At every secant pile location **when:** Beginning of work **who:** Site Engineering Manager

	Problem	Why 1	Why 2	Why 3	Why 4	Why 5	Corrective action	Preventive measure
								How: Make a mature work implementation action plan
	Drill tools are often damaged	Full day tool operation	Lack of routine maintenance and repairs				Routine maintenance when not in use	**what:** Lack of routine maintenance and repairs **where:** Drilling machine parts and crane services **when:** Continue operation **who:** Site Operation Manager and Equipment **How:** Perform routine maintenance every month
Machine :	Not having sufficient stock of spare parts and drill accessories	Lack of material requirements planning					Procure and replace damaged spare parts	**what:** Lack of material requirements planning **where:** Tools and Procurement Section **when:** Beginning of work **who:** Site Operation Manager and Procurement **How:** Procurement and replacement of damaged spare parts
	Less drill tools	The initial contract uses 2 sets of drill tools	The production plan for 2 tools does not match the daily production realization	Lack of planning and action plan tools				**what:** Make a mature action plan and add a set of drilling tools **where:** Tools and Procurement Section **when:** Beginning of work

Problem	Why 1	Why 2	Why 3	Why 4	Why 5	Corrective action	Preventive measure
							Who: Site Operation Manager and Equipment **How:** Make realistic plans and increase the drill tool set

Based on the why-why analysis table regarding the fishbone diagram, several factors were found to cause delays in the secant pile foundation work. The reasons/details of the factors causing the delay are as follows:

A. Man

• Lack of knowledge/competence of operators and technicians regarding the operation of secant pile drilling tools, especially in dam projects, operators lack control of the terrain with the wrong drilling technique, so the drill bit is often stuck in the foundation which results in delays in processing time and damages the structure of the dam foundation. Plus the lack of understanding of technicians in efforts to repair equipment that is experiencing breakdown. This can result in longer repair work times. Moreover, if the breakdown that occurs requires major repairs, this will require technicians from the vendor.

• The number of daily workers is limited, the process of drilling and casting secant pile foundations requires quite a large amount of daily labor, starting from the preparation stage, ironing and casting of the guide wall, installation of the first casing pipe, drilling in the first casing, installation of the second casing pipe, drilling in the second casing , cleaning casing, installing oscillators, installing tremi, installing gutters, to casting piles requires at least 5 people for 1 tool, but the reality in the field is that daily manpower is limited, there are no competent replacement daily workers, with a large work area and more than one set the daily number of tools is less, thus affecting progress in the field

B. Warehouse

• In the warehouse factor, there is accumulation of materials and tools in one work area, where the secant pile foundation that has been drilled and cast is not old enough for drilling work to be carried out. Planning the location of the drill points is random and poorly controlled so that the tool cannot move to other areas resulting in delays in drilling and casting work. For drilling a primary pile to a secondary pile, it must be at least 7 to 14 days old, then drilling can be done on a secondary pile..

C. Machine

• The drill tool is often damaged, due to the absence of routine maintenance and the tool is used full day resulting in the drill tool being damaged which hinders the work of drilling the secant pile foundation.

• Not having sufficient stock of drill spare parts and accessories, due to a lack of planning for the need for goods resulted in the required spare parts not being available in the field which had an impact on hindering the progress of work in the field.

• Available drilling tools are lacking, with damage and maintenance of available tools so as to carry out progress in the field optimizing tools that can still operate, even though the target of secant pile work per day reaches 14 piles per day. By using 2 sets of drilling tools per day only reached 4 piles per day. So that the set of tools available in the field does not balance the target plan per day.

4. Improvement Proposal Draft

The repair plan to be carried out is as follows:
1. Conduct refreshment training for operators and technicians.
2. Make an action plan for the number of workers needed & carry out recruitment of workers.
3. Make an action plan for implementing a mature work area
4. Perform routine equipment maintenance every month
5.Procure and replace damaged spare parts
6.Make realistic planning of tool requirements and add drill tool sets..

A. Man

1. Lack of operator competency and technician skills which is the root of the problem that causes delays in secant pile work at the Semantok Dam. The solution that can be done is to carry out Refreshment Training for Operators and technicians, which aims to improve operator competency and technician skills.
2. The absence of a plan or action plan for the number of workers needed is one of the causes of delays in work in the field. Realization in the field in 1 set of tools there are only 5 people using 2 sets of tools, which means the number of workers per day is only 10 people.

Amount of Power 1 set of tools Normal Hours (1 Group = 5 People)

Energy Productivity = (Realization per day 1 tool)
(Number of Power)
= (3 Pile)/(5 Person) = 0.60 Pile / Person

Power Addition Plan :

(3 Pile)/(4 Pile) = (5 People)/(X)
X = (5 X 4)/3
X = 7 People

Number of Personnel 1 set of additional manpower tools (1 Group = 7 People)

If 5 sets of tools are planned, 7x5 = 35 people/day are needed..

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The solution that can be done is to make a workforce action plan, and if the number does not meet the needs, you have to carry out workforce recruitment.

B. Warehouse

1. Piling up of materials and tools in one place is one of the causes of delays in secant pile foundation work in the field due to a lack of work area plotting planning. The solution that can be done is to make a mature work implementation action plan.

Fig 7:- Sectant Pile Foundation Work Area
Source: Bendungan Semantok, (2021)

The following is the plotting condition of the secant pile foundation drilling work area Before changes are made, where along the secant pile foundation it is only divided into 2 areas and 2 sets of tools, the work location, the drilling area is not properly laid out.

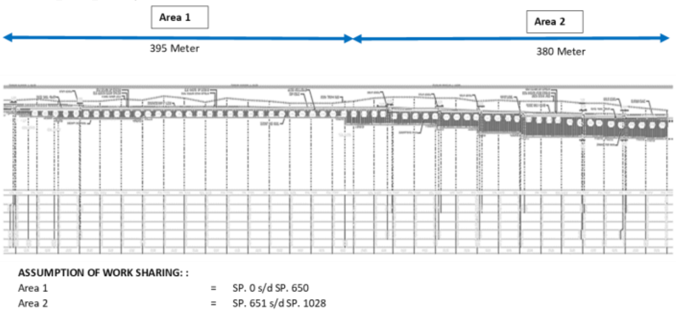

Fig 8:- Area Kerja Sebelum Perbaikan Work Area Before Repair
Source: Author, (2021)

The following is a proposed plot of the secant pile foundation drilling work area using 5 sets of drill tools

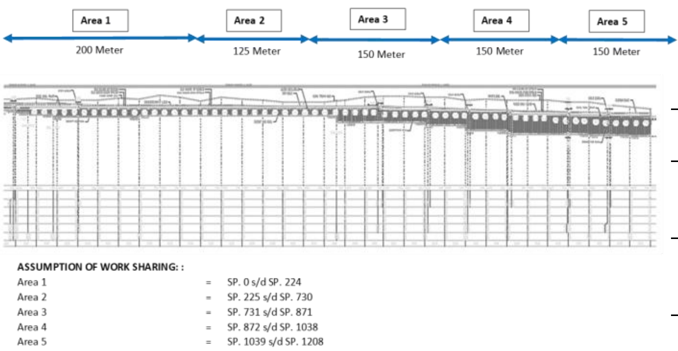

Fig 9:- Proposed Work Area Improvement
Source: Author, (2021)

C. Machine

1. Drilling tool damage is one of the causes of delays in secant pile foundation work in the field due to the absence of routine maintenance. The solution that can be done is to schedule routine maintenance every month so that the machine on the drill is not constrained during use.

Fig 10:- Secant Pile Foundation Drill Tool
Source: Author, (2021)

2. Not having sufficient stock of drill spare parts and accessories is one of the causes of delays in secant pile foundation work in the field due to a lack of planning for material requirements. From the observations of the researchers, the number of available casings at the site was lacking, the drill tool could not drill to the next point because all the casings were still used and still waiting for casting, so the tool could not produce optimally. Then the oscillator tool available cannot serve the total number of drilling points, casting is carried out alternately because the oscillator tool to lift the casing when casting and the verticality test tool is only available one unit while the number of points to be cast is very large.

Table 6:- List Alat dan Aksesoris yang tersedia di lokasi

No.	**Tool Type**	**Unit**	**Before**	**Proposed Additions**	**Dev**	**Position**	**Information**
1	Crane Bor	Unit	2	5	-3	Semantok	3 Xcmg260, 2 Sany280
2	Crane Servis	Unit	2	5	-3	Semantok	3 Swrk85, 2 Puwa55hd
3	Excavator	Unit	2	5	-3	Semantok	2 Sany215, 3 Hyundai
4	Container 20 Feet (Office & Gudang)	Unit	2	5	-3	Semantok	Office Dan Gudang
5	Kelly Bar	Unit	4	10	-6	Semantok	Xcmg260, Sany280(Sany280 2 Lock & Priction)
6	Plat Matras	Lmbr	66	80	-14	Semantok	On Site
7	**Casing Double Wall Dia 880**						
	_ Double Wall Middle P 2 Mtr	Batang	2	6	-4	Semantok	On Site
	_ Double Wall Middle P 3 Mtr	Batang	1	10	-9	Semantok	On Site
	_ Double Wall Bottom P 5 Mtr	Batang	2	8	-6	Semantok	On Site
	_ Double Wall Bottom	Batang	3	6	-3	Semantok	On Site

	_ Shoes Casing / Stater P 0,5 Mtr	Batang	2	6	-4	Semantok	On Site
	Total	Batang	**10**	**36**	-26		
8	Matabor Bucket Ø 800	Unit	6	12	-6	Semantok	On Site
9	Drill Bucket Cleaning Ø 800	Unit	3	6	-3	Semantok	On Site
10	Drill Core Barrel Ø 800	Unit	3	6	-3	Semantok	On Site
11	Auger drill Ø 800	Unit	3	6	-3	Semantok	On Site
12	Casing Brush Bits (Dia 600)	Unit	3	6	-3	Semantok	On Site
13	Casing Brush Bits (Dia 600)	Unit	3	6	-3	Semantok	On Site
14	Genset 60 Kva	Unit	2	4	-2	Semantok	On Site
15	Genset 250 Kva	Unit	3	6	-3	Semantok	On Site
16	Sany Oscillator + Power Pack	Unit	1	2	-1	Semantok	On Site

3. Insufficient drilling tools are the main cause of delays in secant pile foundation work in the field due to a lack of careful planning regarding the need for drill tools to achieve production targets. The solution that can be done is to plan realistic tool requirements and add a set of drill tools. from the observations of researchers, the duration of drilling to casting is quite long. To complete 1 Pile takes 3-4 hours, in one day it can only complete 4-6 Pile, meaning it is far from the target of the completion plan which is targeted at 10-14 Pile per day

Based on the description of the completion work above, to complete 1 pile takes = 182 minutes / pile
= 3 hours / pile / tool

Based on the calculation of the cycle time, the production realization for 1 drill is 3 hours/pile so that the productivity/day is:

8 hours / 3 piles = 3 pi les / day / tool.
Realization of 2 tools = 6 piles / day / tool

With a daily production target of 14 piles per day using 2 sets of drilling tools, it has not been able to complete the secant pile foundation work within 4 months.

The following is a proposed number of tool sets that need to be prepared.
Target = 14 Pile per Day
Production per tool in 1 day = 3 piles / day / tool

Proposed Number of tool sets needed = (14 Pile)/(3 pile)
= 5 Sets of Drill Tools

5. Managerial Implications

The managerial implications in this study are expected to be problem solving that can be applied to dam projects that use other secant pile foundations, this problem solving becomes the author's evaluation material in carrying out subsequent projects and also for other companies in determining and evaluating problems then choosing ways of improvement after knowing the roots problem. There are several implications related to efforts that can be applied to companies from this research, namely as follow:

Table 7:- Managerial Implications

No	Root of the problem	Managerial Implications	
		Before	After
1	Lack of operator competency and technician skills	There is no refreshment training for operators and technicians	Conduct refreshment training held by a team of internal trainers
2	Limited amount of daily power	There is no workforce action plan & recruitment yet	Conduct regular HR recruitment
3	There was a buildup of materials and tools in one place	There is no work area plotting planning, the layout of tools and accessories is messy, and using 2 sets of drill tools	There is a clear and more organized work area plotting plan for drilling locations that are old enough to use 5 sets of drill tools
4	Drill tools are often damaged	There is no tool maintenance, the tool is used full day	Routine maintenance every month or when the tool is not operating
5	Not having sufficient stock of spare parts and drill accessories	Lack of planning for the procurement of accessories for drilling tools and spare parts	Spare parts are available on site when needed and accessories are sufficient, there is no waiting for the drilling process because other drilling tools are still used
6	Less drill tools	2 Drill Tool Sets available do not match the target daily production plan	With the addition of 5 sets of drilling tools, it can complete the secant pile foundation work according to the planned time

V. Conclusion And Suggestions

Based on the research that has been conducted by the author regarding the analysis of delays in secant pile foundation work on the Semantok Dam Project, it can be concluded as follows:

1. The normal cost of the secant pile foundation work at the Semantok Dam is Rp.98,571,230,066 and the Crashing Cost of the secant pile foundation work at the Semantok Dam is Rp.99,035,060,356 with a deviation of Rp.517,830,290 which is more expensive when Crashing adds manpower. Meanwhile, the normal time for the secant pile foundation work at the Semantok Dam is 912 days and the Crashing Time for the secant pile foundation work at the Semantok Dam is 677 days with a deviation of 458 days, which is faster by crashing with an additional workforce.

2. The dominant factors that cause delays in secant pile foundation work at the Semantok Dam are Man, Warehouse, Machine factors. Where is the Man factor, namely the lack of competence of operators and technicians due to the absence of refreshment training, the number of daily workers is limited because they have not carried out regular HR recruitment. The Warehouse factor is the accumulation of materials and tools in one place due to a lack of work area plotting planning. The machine factor, namely the drill tool is often damaged due to lack of maintenance and routine repairs, does not have sufficient stock of drill spare parts and accessories due to a lack of planning for the need for goods, the drill tool is lacking due to a lack of planning and tool action plans. Corrective actions that must be carried out are Man: Carrying out refreshment training for operators and technicians, make an action plan for the number of workers needed & carry out recruitment of workers. Warehouse: Make an action plan plotting a mature work implementation area. Machine: Perform routine maintenance every month, procure and replace damaged spare parts, make realistic plans and add drill sets.

Based on the research that has been carried out by the author regarding the work of secant piles at the Semantok Dam, the authors provide suggestions for both readers and for further researchers and contractors, including the following:

1. In carrying out work, especially critical items, it is better to always evaluate the realization of the plan and immediately follow up on problems related to the daily realization failure so that the completion of the work is according to the expected target.

2. The work plan and the number of tool sets needed to be used in the next similar project must be carefully calculated before being implemented so that the realization is achieved according to the planned target.

3. In selecting Vendors or Subcontractors, especially in the use of heavy equipment, make sure the subcontractor procures new equipment or according to the specifications so that the equipment used has maximum performance

4. Risk Management (ManRisk) for the next project should be improved so that the gap between the plan and the realization is monitored and evaluated every day.

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