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Design of Drainage System Coal Mine at PT. Tebo Agung International Site Project, Semambu Village, Sumay District, Tebo Regency, Jambi

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Abstract
Tebo Agung Internasional Ltd is one of the companies in coal mining that employs the open-pit mining method. This sort of method will create a large basin that can accumulate water inside the mining pit. The drainage system is applied at the Pit-1 Site Semambu is mine-dewatering carried out by draining the water into the sump so that it can be pumped out of the mining area and prevent the runoff from coming inside through an open drainage system (ditch). The result of data analysis demonstrated that referring to the daily rainfall in 2010 – 2019 through the distribution of Log Person Type III, the maximum rainfall being planned was 508.019 mm/day within the return period of 5 years. The intensity of rainfall at the research site was 82.5 mm/hour having a rain duration averagely of 3.1 hours/day. Pit-1 Site Semambu had a catchment area around 469,317.15 m^2 and a water discharge totally 61,238.81 m^3/day derived from rainwater discharge of 48,530.48 m^3/day and runoff water discharge 12,708.33 m^3/day, whereas the capacity of the temporary accommodating pond (Sump) was 39,539.55 m^3. The pump at the research site could not be operated anymore (broken). Accordingly, the recommendation that can be given to the company is changing the broken pumps with 4 units of multi fall 420 pumps having operating speed 1,300 rpm and actual discharge yielded by the pump 871.64 m^3/hour. The pump worked for 14 hours/day and the total water discharge that could be produced was 12,202.96 m^3/day. Open channel (ditch) at Pit-1 Site Semambu was the only one with accommodated discharge 1.27 m^3/second. Thus, the recommendation that could be delivered to optimally prevent the runoff water coming into the mining area is by adding 2 ditches having the capacities of 0.90 m^3/second and 0.75 m^3/second which have been adjusted to the planned water discharge.

1. Introduction

Tebo Agung Internasional Ltd applies this open-pit method, which all activities are directly related to weather and climate, causing the mining front to face the water from rain and runoff. In supporting the mining production process, a mine drainage system is needed, so that at PT. Tebo Agung International various infrastructures are made to control water flowing in the mining area, especially on the mining front.

The water treatment system in this area is given more attention because it is directly related to mining activities which are always mobile in line with the mining depth. Improper flow planning can cause problems in mining, which often occurs is the amount of water that enters or is stagnant which disrupts mining activities.

In supporting the running of mining activities, an effective and efficient mine drainage system is needed, marked by the absence of water at the mining front so it is necessary to install pumping so that pumping activities can work properly and create safe and comfortable working conditions for mine workers who can have an impact. on the amount of production that will be produced by PT. Tebo Agung International.

The distribution of rainfall data that occurs in Jambi province, especially in the mining location of the research area, is one of the important information in planning the mine drainage system so that researchers focus on collecting rainfall data, DTH area, actual conditions of sumps, and gullies. Mining activities have the main objective of controlling water entering the mining area to an area that does not interfere with mining activities. So that it can support the smooth running of mining production.

2. Methodology

Mine Flow Method

The source of water that enters the mining area comes from surface groundwater and underground water. Ground surface water is water that is present and flows on the ground surface. This type of water includes surface runoff water, river water, swamps or lakes in the area, wastewater (waste), and springs. Meanwhile, underground water is water that is present and flows below the ground surface. This type of water includes groundwater and seepage water. Handling water problems in an open pit can be divided into two[1].

Mine Drainage

Is an effort to anticipate water entering the mining area. This method is generally applied to the treatment of groundwater and water originating from the surface.

Mine Dewatering

Is an activity to remove water that has entered the mining area. This activity is mainly to deal with water that comes from rainwater.

Topographic Conditions

Water flows from high topography to low topography. Before becoming a source of water from a drainage system, the water will pass through several ground surface conditions such as vegetation density, topographic conditions, and geological conditions. This condition affects the size of the runoff discharge, by taking into account the runoff coefficient from the area.[2]

Table 1. Research Area Runoff Coefficient

Slope	Land Use	Runoff Coefficient
< 3% (Flat)	Rice fields, swamps	0.2
	Forest, Plantation	0.3
	Housing with Gardens	0.4
3 % - 5 % (Moderate)	Plantation Forest	0.4
	Housing	0.5
	Rare Plants	0.6
	No Vegetation, Growing Area	0.7
> 15% (Steep)	Forest	0.6
	Housing, Garden	0.7
	Rare Plants	0.8
	Without Vegetation, Mining Area	0.9

2.1. Rainfall

The unit of rainfall is mm which means the amount of rainwater that falls in a certain unit area. So 1 mm means that on an area of 1 m2 the amount of water that has fallen is 1 liter. The degree of rainfall is expressed in terms of rainfall per unit time and is called the intensity of rainfall, which states the size of rain [3].

Rainfall data processing is carried out to obtain the maximum planned rainfall value and the maximum rainfall intensity value. The method used for the calculation of rainfall is the Log Person Type III method and the Mononobe equation for rainfall intensity. The formula for Log Pearson III is: [4]

$$\log X_T = \overline{\log X} + K_{TR}\,\overline{(S \log X)} \quad (1)$$

$$\overline{S \log X} = \sqrt{\frac{\sum_{i=1}^{n}(\log X_i - \overline{\log X})^2}{n-1}} \quad (2)$$

The skewness slope factor (Cs) is calculated by the formula:

$$Cs = \frac{n\sum_{i=1}^{n}(\log X_i - \overline{\log X})^3}{(n-1)(n-2)(\overline{S \log X})} \quad (3)$$

Where $\log X_i$ = logarithm of all X

Information:

Xt	= Rainfall plan with return period t years (mm)
$\bar{X}$	= Average rainfall (mm)
K	= frequency factor
K_{TR}	= Skew curve factor or skewness inclination factor
SD	= Standard deviation

Rainfall Intensity :

$$I = \frac{R_{24}}{24}\left(\frac{24}{t}\right)^{2/3} \quad \textit{(4)}$$

Information :

I	= Rain intensity (mm / hour)
R_{24}	= Rainfall 24 hours / day (mm)
T	= Duration of rain (hours)

2.2. Mine Water Discharge

Mine water discharge is a water discharge consisting of rainwater that directly enters the mining area (pit) and runoff water. The amount of water discharge depends on the runoff coefficient, the amount of rain intensity, and the area of the rain catchment area.[5]. Mine water discharge is a water discharge consisting of rainwater that directly enters the mining area (pit), runoff water, and groundwater. The discharge of mine water is what will be used as a determination to calculate the dimensions of the open channel.[1]. Rainwater discharge is the amount of water discharge that directly enters the bottom pit area or the lowest area in the pit. The water discharge comes from rainfall in the area.[5].

$$Q = Xr \; x \; A \quad \textit{(5)}$$

Information :

Q	= Rainwater discharge (m^3 / sec)
Xr	= Rainfall (mm)
A	= The area of the bottom pit (m^2)

The discharge of runoff water (peak runoff = Qp can be calculated using a rational method (US Soil Conservation Service, 1973).[3]

$$Qp = 0{,}278 \; x \; C \; x \; I \; x \; A \quad \textit{(6)}$$

Information :

Qp	= discharge of runoff water (m^3 / sec)
C	= runoff coefficient
I	= rain intensity and (mm / hour)
A	= area of rain catchment (Ha)

2.3. Open Channel

The open channel serves to drain water that will enter the mining area to a predetermined area. The selection of the dimensions of this channel is based on considerations of water discharge, the type of soil in making the open channel, and the method of making it. There are several kinds of open channel shapes such as trapezoid, semicircle, triangle, and square shapes. Parameters to determine open channel include mine water discharge, channel wall hardness coefficient value, the average slope of the channel bottom, and wet cross-sectional area [2]. The drainage system is an attempt to prevent, dry, and remove water from inundating a certain area [1]. The calculation of the drainage capacity of a water channel is carried out using the Manning formula as follows [1]:

$$Q = 1/n \text{ x } R2/3\text{x } S1/2\text{x } A \quad (7)$$

Information:

Q = Discharge (m^3 / sec)
R = hydraulic radius (m)
S = slope of the channel (%)
A = Wet cross-sectional area (m^2)
N = Manning roughness coefficient

2.4. Sump

Sump for a while before it is pumped out of the mine area. Therefore, the dimensions of the well depend on the amount of water discharge that enters and leaves the well. The amount of water that enters the well comes from the flow of water channels, the amount of surface runoff that directly flows into the well, and rainwater that directly falls into the well. Meanwhile, the amount of water that comes out is based on the pump capacity used. Therefore, the dimensions of the well can be determined based on the optimization of input and output.[5]

2.5. Pumping System

A pump is a tool that functions to move fluids from one place to another by increasing the liquid pressure. To overcome the flow barriers, an increase in liquid pressure is used. In choosing a pump, things that need to be considered include the maximum discharge of mine water, the length of the pumping time, the need for pump discharge, the total head, the type and size of the pump.[6]

The discharge value of a pump can be determined based on existing specifications or by manually measuring the actual flowrate.[6]

$$Qpompa = \pi \, x \, r^2 \, x \, v \quad (8)$$

$$\text{v} = \frac{x}{\sqrt{\frac{2y}{g}}} \quad (9)$$

Information :

Pump = Actual discharge of pump outlet (m^3 / sec)
R = the radius of the pipe used by the company (m)
V = Flow velocity (m / s)
x = Pump outlet shot length (m)
y = the length of the short side of the measuring instrument used (m)
g = Acceleration due to gravity (9.8 m / s^2)

3. Results

Mine Drainage System

Tebo Agung Internasional Ltd in implementing its drainage system uses the mine dewatering method with an open pond and ditch system. This system removes the water collected in the sump, then discharges it using a pump[7]. Meanwhile, those outside mining use a trench system, where runoff water that will go to the mine is directly collected in a ditch (channel) before entering the mine. After being in the ditch, the water is immediately flowed into the settling pond and the river. This can be seen from the object of research, namely the mining pit. And it is known that the mining system implemented by the company is an open-pit, where all activities are directly related to the outside air. From topographical observations, it can be seen that the mining pit (research object) has a lower elevation than the rain catchment area.

Open Channel Discharge

At PT. Tebo Agung International, there is an open channel totaling 1 channel. The channel functions to drain the water discharge from DTH 1 and 3. The channel has been designed with the appropriate dimensions and can accommodate the incoming runoff water discharge. So there is no need for a redesign. The open channel is rectangular with consideration of relatively easy maintenance and cheaper manufacturing costs. The following (table 2) is a comparison of the open channel capacity with the planned discharge.

Table 2. Comparison of Open Channel Capacity with Design Discharge

Information	**DTH_1**	**DTH_3**
The incoming water discharge	0,444 m^3/Second	0,489 m^3/ Second
Channel Capacity	1,27 m^3/ Second	1,27 m^3/ Second
Information	Covered	Covered

Sump

Based on observations and calculations using software assistance, the total area of the three sumps is 7,907.91 m^2 and has a depth of 5 meters. Then the total volume capacity of the sump in the study area is 39,539.55 m^3. For more details, see table 3.

Table 3. Volume of *Sump*

No	Sump	Wide (m^2)	Height (m)	Volume (m^3)
1.	I	5.378,31	5	26.891,55
2.	II	1.677,53	5	8.387,65
3.	III	852,07	5	4.260,35
		Total		39.539,55

The total water discharge in the sump is the flow of rainwater that falls directly into the pit bottom area. In the calculation of sump water discharge, an assessment of the groundwater discharge is not carried out because the lowest mining pit or pit bottom does not reach groundwater, so in the calculation of the sump water discharge, the groundwater discharge does not affect (equal to zero). So that the total discharge of rainwater that enters the sump is 48,530.48 m^3 / day. Based on the results of research in the field, the ability or capacity of the sump to hold water is 39,539.55 m^3. So with this condition, it shows that the existing sump capacity is not able to accommodate the total flow of incoming rainwater. Therefore, the researcher focuses on the number of pumps to be used and maximizes the working power of the pump.

4. Discussion

Mine Flow Management System

a. Pumping Management

In handling water in the sump area, it is necessary to handle the appropriate pumping efforts. So that the researchers took the initiative to help plan the type of pump according to the actual conditions in the Sump area. Therefore, the researchers planned 4 pump units with the multi-fall 420 types with an operating speed of 1,300 rpm with an operating time of 14 hours/day. The pipe used is a type of HDPE pipe with a diameter of 12 inches, a length of 88 meters, and a length of 3 meters of the suction pipe. The reason the researchers plan for 4 pump units is based on the calculation of the maximum flow of rainwater that enters on the first day it can be issued with 1 pump unit but it only leaves little room for sump capacity (the water is not drained out), and if the next day it rains with the same discharge. , then the sump capacity can no longer accommodate (overflow) even though 1 pump unit continues to work. So to overcome this, the researcher has adjusted the number of pumps that must be used, namely 4 units with the amount of water discharge that enters the sump.

From the measurement results using the discharge method, the actual discharge capable of being released by the pump is 871.64 m^3 / hour. With the pump working hours for 14 hours per day, the total water discharge that can be released is 12,202.96 m^3 / day. And the actual head size obtained is 98.65 m. PT. Tebo Agung International has 2 work shifts and in 1 shift there are 7 working hours. The pumps at PT. Tebo Agung International operates for 7 hours in 1 shift so that in 1 day it works for 14 hours. The total flow of water that can be pumped by 4 Multiflo 420 pump units simultaneously is 48,811.84 m^3 / day. The use of the Multiflo 420 pump with an operating speed of 1,300 rpm with an operating time of 14 hours/day is adjusted to the rain conditions or the intensity of the rain that occurs. If it rains with low intensity, it is only used with an operating time of 13 hours/day. If there is rain with high intensity, then the operating time of the pump will be maximized again up to 14 hours/day. However, considering that the pump needs to be properly maintained, periodic checks, and refueling, there will be no increase in pump working hours exceeding 14 hours.

b. Ditch Addition Management

The design of the open channel (ditch 1) for the first rain catchment area has an area (A) of 0.92 m², the bottom width of the channel (b) is 0.5 m, the depth of the water surface (h) is 1 m, the width of the channel surface (B) 1 m, the channel tilt angle is 60 °, and the channel length is 387.53 m. This open channel design (ditch 1) aims to drain some of the runoff water from DTH I directly to Settling Pond 1. As for the open channel design (Paritan 2) for the second rain catchment area, it has an area (A) of 0.77 m². , channel bottom width (b) 0.35 m, water surface depth (h) 1 m, channel surface width (B) 0.7 m, channel slope angle of 60 °, and channel length 360.95 m. This open channel design (ditch II) aims to drain runoff water from DTH II directly into the river flow.

The two open channels are designed with dimensions that the researchers have adjusted according to the incoming runoff discharge. Trapezoid-shaped open channel with consideration of relatively easier maintenance and cheaper manufacturing costs. The following (Table 4) is a comparison of the open channel capacity with the planned discharge.

Table 4. Comparison of the design capacity of the ditch with the planned discharge

Information	DTH_1	DTH_2
The incoming water discharge	0,444 m^3/Second	0,206 m^3/Second
Channel Capacity	0,90 m^3/Second	0,75 m^3/Second
Information	**Covered**	**Covered**

5. Conclusion

The drainage system applied in the research area is mine dewatering. This is because the systems used in the study area are the well system (Sump) and the open channel system (Trench) which are part of the mine dewatering method. The open channel (ditch) in the study area has a channel capacity of 1.27 m^3 / second, which indicates that the channel capacity is greater than the planned discharge so that it can accommodate the incoming water discharge. The sump in the study area has a capacity of 39,539.55 m^3, with a total flow of rainwater that enters the sump of 48,530.48 m^3 / day. So with this condition, it shows that the existing sump capacity is not able to accommodate the total flow of incoming rainwater so that it will be focused on planning the number of pumps and increasing the working power of the pumps.

The management of the drainage system in the study area is divided into 2 aspects, namely pumping management and drainage management. In the research area, there is no proper pumping system, so the researchers plan 4 pumps with the type of multifalo 420 with an operating speed of 1,300 rpm with an operating time of 14 hours/day. The pipe used is a type of HDPE pipe with a diameter of 12 inches, a length of 88 meters, and a length of 3 meters of the suction pipe. From the measurement results using the discharge method, the actual discharge that can be issued by the pump is 871.64 m3 / hour or 12,202.96 m3 / day. The design of the open channel (ditch 1) for the first rain catchment area has an area (A) of 0.92 m², the bottom width of the channel (b) is 0.5 m, the depth of the water surface (h) is 1 m, the width of the channel surface (B) 1 m, the channel tilt angle is 60 °, and the channel length is 215.92 m. This open channel design aims to channel some of the runoff water from DTH I directly to

Settling Pond 1. As for the open channel design (Paritan 2) for the second rain catchment area, it has an area (A) of 0.77 m², the width of the channel base. (b) 0.35 m, water surface depth (h) 1 m, channel surface width (B) 0.7 m, channel slope angle of 60°, and channel length 280 m. This open channel design aims to drain runoff water from DTH II directly into the river flow.

6. Acknowledgment

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References:

[1] Gautama Yudi Sayoga, 1993, "*Sistem Penyaliran Tambang*", Institut Teknologi Bandung, Bandung.
[2] Chayadi, Tedy Agung., 2007.Rancangan Sistem Penyaliran Tambang Terbuka, PT.Myokoindo Daya Gemilang. Yogyakarta
[3] Asdak Chay.2010.Hidrologi dan Pengelolaan Daerah Aliran Sungai. Yogyakarta. Universitas Gajah Mada.
[4] Gumbel, E.J. *Statistical theory of extreme values and some practical applications. Applied Mathematics Series 33 (1st ed)*. Depratement of Commerce. National Bereau os Standards. 1954
[5] Endriantho Muhammad dan Ramli Muhammad, 2013. *Perencanaan Sistem Penyaliran Tambang Terbuka Batubara*.
[6] Tahara. Haruo. 2004. *Pompa dan Kompresor*. Jakarta : PT. Pradnya Paramitha.
[7] F. A. Redanto Putri, "Kajian Teknis Sistem Penyaliran Tambang Batubara pada Tambang Terbuka di PT. X," *J. IPTEK*, vol. 24, no. 1, pp. 59–66, May 2020, doi: 10.31284/j.iptek.2020.v24i1.902.