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DRAIN HOLE INSTALLATION DESIGN IN AN OPEN COAL MINE

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Abstract
The presence of groundwater on the mine slopes can disturb the stability of the slope. High groundwater can increase pore pressure which affects the amount of load on the mine slope. In order to lower the groundwater level, it is necessary to have drainage holes to drain water naturally. This study aims to design a horizontal drain installation so that it can lower the groundwater table. The results of this study indicate the existence of an aquifer in the form of sandstones. In this aquifer horizontal drains will be installed. The results of this study are in the form of horizontal drains installation design, namely, the location of the installation of the horizontal drain, the diameter of the boreholes, the distance between the boreholes, the length of the horizontal drains installation pipe, and the angle of inclination of the installation of the horizontal drains.
Keywords: *Groundwater, aquifer, horizontal drains*

INTRODUCTION

Groundwater found on the slopes of the mine can disrupt the stability of the slopes. High groundwater levels can cause increased pore pressure that affects the amount of l qoad on the slopes of open-pit mines so that the strength of a slope's constituent rock mass decreases. This can result in human safety and units operating in mining areas are at a high risk of danger. The decrease in groundwater level on the slope will lead to an increase in the value of the slope Safety Factor (Frans, 2019)

To lower the groundwater face drainage holes are necessary to drain the water naturally. Horizontal channels are defined as holes drilled into slopes or embankments and wrapped in perforated metal (Royster, 1980). Horizontal decomposition channels are used as part of more complex remediation schemes, often installed to reduce the increased groundwater effect in slope stability projects (Cook et al, 2012). The purpose of using horizontal draining as part of the work of controlling the occurrence of landslides by draining groundwater, thus keeping the soil dry (Rahardjo, 2002). A few drainage holes that fit the well-targeted conceptual model in the installation are better than a large number of uniformly installed channels (Martin et al, 1994). The selection of a limited drain hole placement scheme in the field is essential to optimize the role of drain holes by maximizing the distribution information of hydraulic conductivity distribution (Cahyadi et al, 2016). The length of horizontal drainage holes is generally shorter than vertical drainage spares, thus saving operational costs (Cahyadi et al, 2018).

The purpose of this study is to find out the type of aquifers and lithology, making a technical design of horizontal drains installation in the research area which includes the installation site of horizontal drains, the diameter of drill holes, the distance between drill holes, length of horizontal pipe drains, and horizontal slope angle of drains.

METHOD

The research location is in Mangkalapi Village, Kusan Hulu District, Tanah Bumbu Regency, South Kalimantan Province. The research approach can be done through the grounded research approach, which is a direct research activity and all activities are carried out in the field (Wibisono, 2013). The research phase has several stages, namely literature study, field observation, data retrieval, and data processing and analysis. Tools and materials used for data retrieval are meters, a geological compass, GPS, a geological hammer, clipboard, and stationery. Data retrieval techniques by mapping lithology so that the type of lithology, lithology spread, and aquifer type in the research area can be known. The results of lithology mapping are combined with drill hole data from the company and processed in *minescape* software to know the model of subsurface geology so that it can be used to determine the location of horizontal drains installation. The flow chart can be seen in Figure 1.

RESULT AND DISCUSSION

Lithology mapping is done to find out the kinds of lithology in the research area, the thickness of rock layers, the spread of rocks, and the properties of rock Isik (See table 1). Sandstone is a lithology that has the potential to be a good aquifer because it has good permeability, whereas claystone is judged not good enough as an aquifer. This lithology mapping data will be used to determine the position of a potential aquifer lithology, namely sandstone lithology as the basis for making horizontal drains design.

Regionally groundwater in the research area is strongly influenced by hydraulic gradient and rock permeability. Based on the data in 2019 in the research area obtained hydraulic conductivity value (K) ranging from 0.51 x 10-7 - 3.60 x 10-7 m / s, the potential of groundwater is low to moderate value (Todd, 2005). There is one type of aquifer that is a depressed aquifer. This aquifer is found in the lithology of fine to medium-sized stone. It is on this aquifer that horizontal drains will be installed.

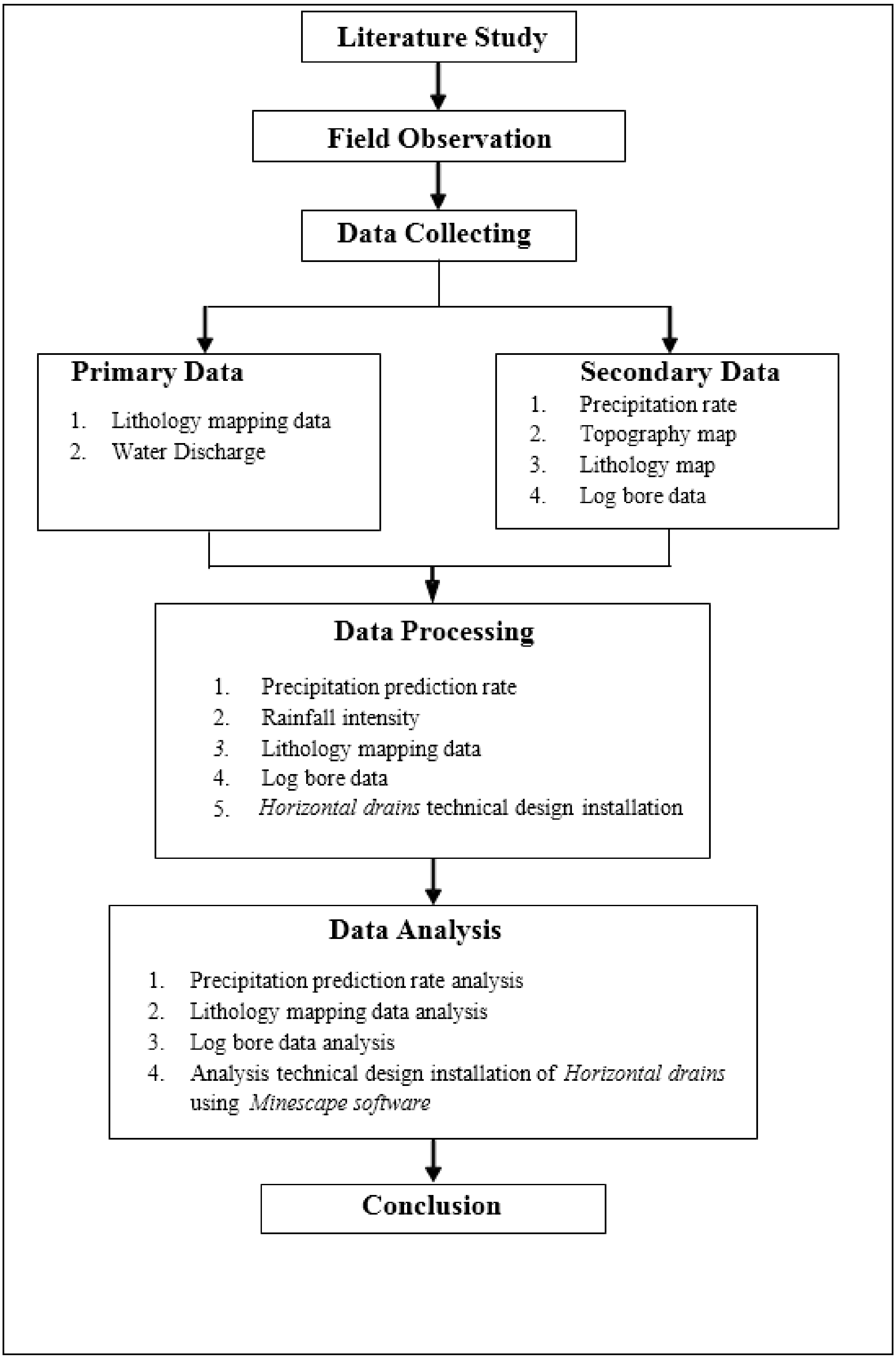

Figure 1. Research Flow Chart

Table 1. Lithology description in the research area

No	Lithology	Description
1	Dark Clay Stone	Color: dark gray, rock structure: layering, mineral composition: silica, permeability: impermeable, rock type: clay
2	Bright Clay Stone	Color: light gray, rock structure: layering, mineral composition: silica, permeability: impermeable, rock type: clay
3	Sandstone	Color: light gray, rock structure: layering, grain size: fine-medium, degree of fertilization: round, degree of sorting: bad sorting, mineral composition: quartz; hornblende; lytic, permeability: permeable, rock type: sandstone
4	Coal	Color: black, lighting: faded, mineral composition: carbon, rock type: coal

To find out the appropriate location for the installation of horizontal drains, lithology mapping has been done in the research area, so that a geological model is obtained to know the location and the termination of each lithology. From the results of geological mapping processing obtained that the installation of horizontal drains will be installed at the 7th, 8th, and 9th levels (See table 2), because at this level is considered to be at the most effective location to install horizontal installation drains until it penetrates the aquifer layer (See figure 2). It is considered effective because at this level it is closest to the aquifer compared to other levels.

Table 2. Location of drain hole point

Drain Hole Name	X Coordinate	Y Coordinate	Level
DH 1	2645	16149	7
DH 2	2613	16187	7
DH 3	2589	16234	8
DH 4	2557	16772	8
DH 5	2525	16509	8
DH 6	2492	16348	8
DH 7	2469	16394	9
DH 8	2435	16430	9
DH 9	2395	16462	9
DH 10	2348	16485	8

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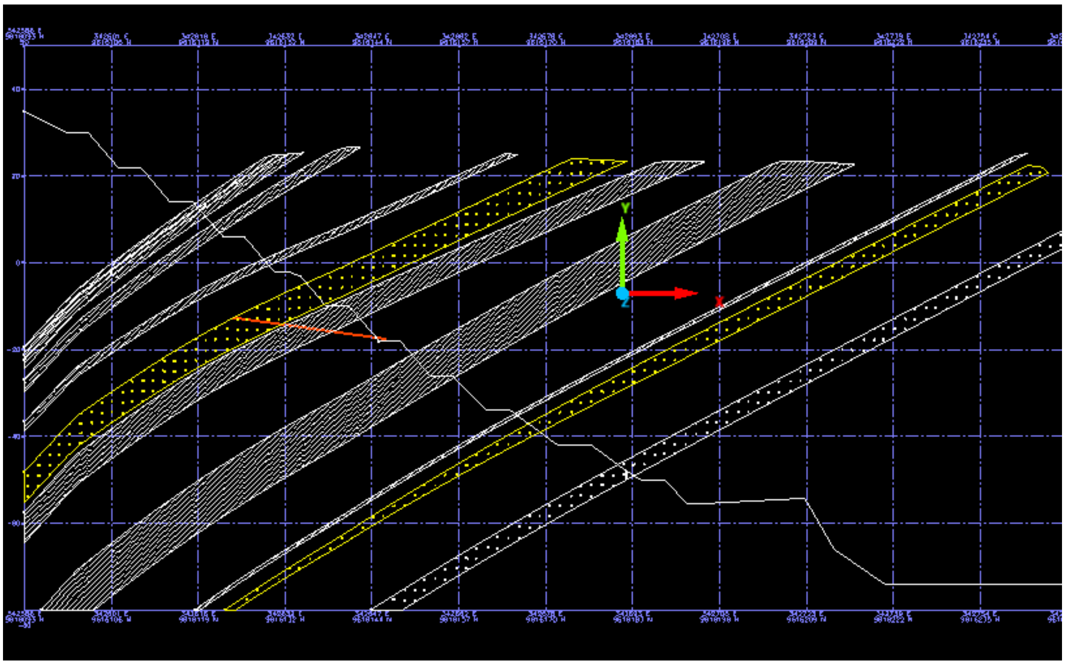


Figure 2. The installation location of horizontal drains

The diameter of the pipe is determined based on the total discharge of groundwater emitted and the length of the pipe to be used until it penetrates the aquifer layer so that it can accommodate the discharge of aquifer water, the diameter of the pipe is also adjusted to the diameter of the available drill tools recommended by the company. The diameter of horizontal pipe drains to be used is PVC pipe with a diameter of 1 1/4 inch. Diameter 1 1/4 inch is the diameter that is considered the most effective because it can accommodate the discharge of aquifer water issued. water volume that can be accommodated with a diameter of 1 1/4 inch with a pipe length of 25 meters:

$$V = \mu \times r^2 \times t$$
$$= 22/7 \times 1{,}5875^2 \text{ cm} \times 2500 \text{ cm}$$
$$= 19.800{,}42 \text{ cm}^3 = 19{,}8004 \text{ liter}$$

While the diameter of the drill hole to be used is a type of NQ diameter of 2 inches. The distance between drill holes is determined based on groundwater discharge at the research site divided by the length of the location to be installed horizontal drains so that the distance between the drill holes is most effective and economical. Based on the results of the test well in the research area obtained groundwater discharge 15,625 x 10-4 m3 / s or 1.56 liters / second with a track length of 594 meters, so that in 1 meter obtained a discharge of 0.0026 liters/second. In determining the distance is taken into account also how many pipe drill holes can accommodate the discharge of water. The distance used is 50 meters between the drill holes.

Space 50 meter = water discharge/meter x space
= 0,0026 liter/second x 50
= 0,13 liter/second

So with a distance of 50 meters between drill holes, each drill hole can release a water discharge of 0.13 liters/second.

To determine the length of the pipe, lithology mapping has been done at the research site, so that a geological model is obtained. From this geological model, it can be known how long the pipe is until it penetrates the aquifer. The length of each pipe is different according to the existence of rock lithology in the research area (see table 3). Pipes are installed until they heal the aquifer layer, which is in the lithology of the plastic stone.

Table 3. Location of drain hole point and pipe length

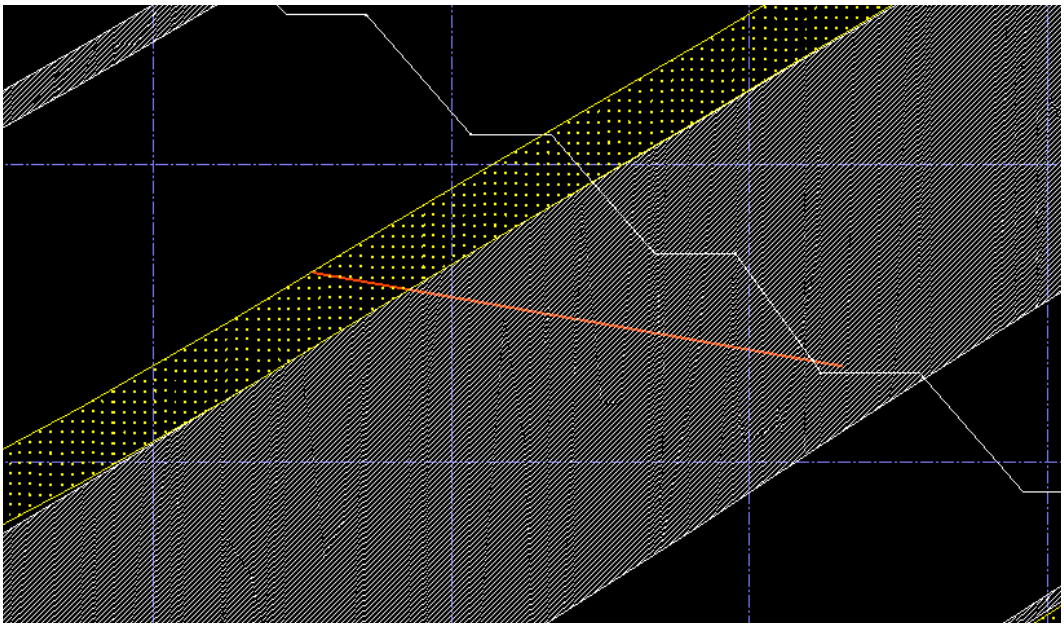
No	Point ID	Length	Level	No	Point ID	Length	Level
1	HD1	36 m	7	6	HD6	27 m	8
2	HD2	30 m	7	7	HD7	45 m	9
3	HD3	48 m	8	8	HD8	39 m	9
4	HD4	42 m	8	9	HD9	45 m	9
5	HD5	36 m	8	10	HD10	48 m	8

Horizontal drains are used by utilizing gravitational forces so that they are made with a certain loudness. The angle of inclination suitable for lithology of clay and clay is 5°-10° (Santi, 2001). The angle of inclination used in this design is 8° (See figure 3).

The slopes were previously unsafe due to several factors, one of which was due to the presence of groundwater, after the installation of horizontal drains the level of saturation on the slope was reduced so that the slope became more stable and safe.

There is another alternative to determine the distance between drainage holes by using a spreadsheet from (Cook et al., 2012) (See table 4). Specifically, these spreadsheets can be used quickly:

1. Predict piezometric surfaces on drained slopes for use in slope stability analysis.
2. Predict the head in the piezometer mounted on the drained slope to verify the expected drawdown.
3. Approximate average drainage distance appropriate to achieve the desired piezometric drawdown



Gambar 3. Tilt angle of horizontal drains installation

Here's the data input needed in this spreadsheet:

Table 4. Input data spreadsheet

Objective	Parameter	Value
Input Data to Calculate Drain Spacing or Maximum Piezometric Profile:	Hydraulic Conductivity (m/s) - **K:**	2.01E-07
	Average Drain Outflow From a Single Drain (m^3/s) - **Q:**	
	Recharge over area LxS (m/s) - **V:**	9.75E-09
	Average Drain Length (m) - **L:**	39
	Average Drain Spacing (m) - **S:**	50
	Average Depth to Underlying Low-Permeability Layer (m) - **D:**	
	Drain Radius (m) - $\mathbf{r_0}$**:**	0.03175
	Drain Angle (degrees) - **α:**	8
	Low-Permeability Layer Angle (degrees) - **φ:**	5
	Multiplier - **M:**	0.72
	Initial Piezometric Head Behind Drain Field (m) - $\mathbf{H_i}$**:**	5.5
	Elevation of Drain Outlet (m) - $\mathbf{E_{do}}$**:**	0.61
	Elevation of Low-Permeability Layer Below the Drain Outlet (m) - $\mathbf{E_{lp}}$**:**	0

By entering data such as the table above obtained results in the form of piezometer surface prediction graphs on drained slopes (Figure 4 and Figure 5). From this graph, it can also be known whether the average drainage distance used is appropriate to achieve the desired piezometric drawdown. On this chart, the length of the horizontal drains used is 39 m. The green line shows the drain, the red line shows the low permeability layer, and the blue line shows the piezometric surface. The chart with an average distance of 50 m has not reached the optimal piezometric drawdown because there is still a distance between the piezometric surface and drain, the groundwater level drop is slower compared to the average distance of 10 m, while with an average distance of 10 m can reach the optimal piezometer drawdown and the groundwater drop is faster than the average distance of 50 m. To find out the advantages and disadvantages of using a distance of 10 meters and 50 meters can be seen in table 5.

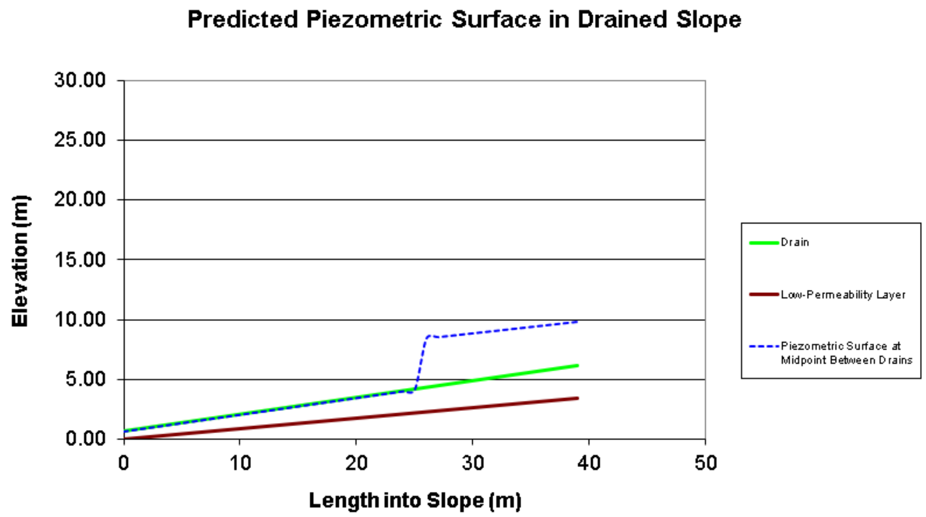


Figure 4. Graph with drainage spacing of 50 m

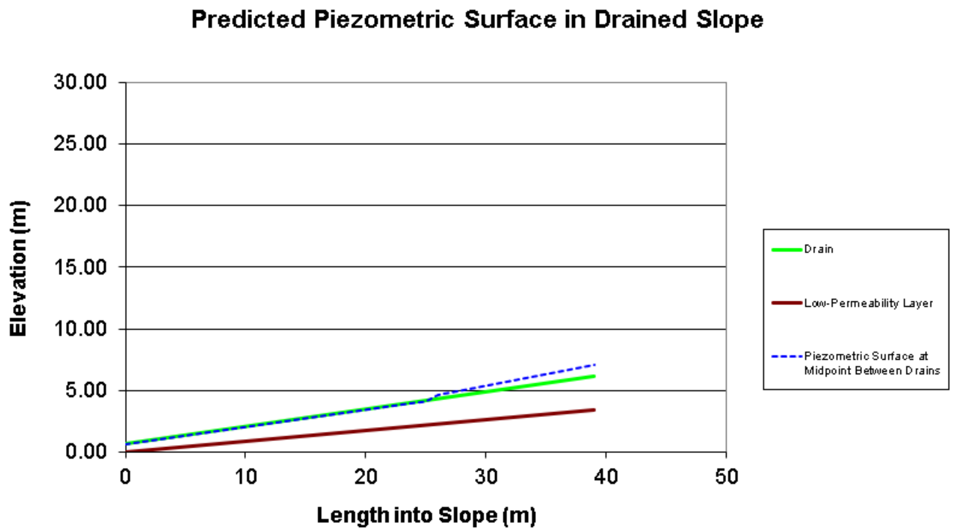


Figure 5. Graph with drainage spacing of 10 m

Table 5. Comparison of drainage distances of 10 m and 50 meters based on Diana Cook spreadsheet

Information	10 m	50 m
Advantages	Can lower groundwater level faster	Cheaper cost
Disadvantages	Cost more expensive	Lowering groundwater level is lower than the distance of 10 m

CONCLUSSION

Based on the results of research in the field, data analysis, and studies, it can be concluded as follows:

1. The type of aquifers found at the research site is depressed aquifers found in the lithology of the stone that has a fine-medium grain size.
2. *Horizontal drain* installation design:
   a. The location of horizontal drains installation will be installed at levels 7, 8, and 9 because at this location the most effective to install horizontal installation drains until it penetrates the aquifer layer.
   b. The diameter of horizontal drill hole drains is 2-inch in size by using the Jinzhou Shitan drill tool. And the diameter of the plumbing size 1 1/4 inch
   c. The distance between drill holes that are considered effective and economical is 50 meters between drill holes
   d. The length of horizontal drains installation pipe varies by point according to the position of the aquifer, which is between 27-48 meters until it penetrates the aquifer layer
   e. The angle of inclination used is 8º to make use of the gravitational force.

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REFERENCES

Cahyadi, T. A., Widodo, L. E., Fajar, R. A., & Baiquni, A. (2018, December). Influence of drain hole inclination on drainage effectiveness of coal open pit mine slope. In *IOP Conference Series: Earth and Environmental Science* (Vol. 212, No. 1, p. 012060). IOP Publishing.

Cahyadi, T. A., Widodo, L. E., Syihab, Z., & Notosiswoyo, S. (2017). Pengaruh Instalasi Drain Hole Terhadap Penurunan Muka Airtanah Pada Media Permeabilitas Yang Berbeda (studi Kasus Model Konseptual).

Cook, D. I., Santi, P. M., & Higgins, J. D. (2012). Prediction of piezometric surfaces and drain spacing for horizontal drain design. *Landslides*, *9*(4), 547-556

Martin, R. P., Siu, K. L., & Premchitt, J. (1994). Review of the performance of horizontal drains in Hong Kong. Special Project Report, SPR 11/94. *Geotechnical Engineering Office, Civil Engineering Department, Hong Kong*, *106*.

Rahardjo, H., Hritzuk, K. J., Leong, E. C., & Rezaur, R. B. (2003). Effectiveness of horizontal drains for slope stability. *Engineering Geology*, *69*(3-4), 295-308.

Royster, D. L. (1980). Horizontal drains and horizontal drilling: an overview. *Transportation Research Record*, *783*, 16-20

Santi, P. M., Dale Elifrits, C., & Liljegren, J. A. (2001). Design and installation of horizontal wick drain for landslide stabilization. *Transportation research record*, *1757*(1), 58-66.

Santo Frans, J., & Nurfalaq, M. H. (2019). STUDI GEOTEKNIK PENGARUH MUKA AIR TANAH TERHADAP KESTABILAN LERENG TAMBANG BATUBARA. *Prosiding Temu Profesi Tahunan PERHAPI*, *1*(1), 475-488.

Todd, D. K., & Mays, L. W. (2004). *Groundwater hydrology*. John Wiley & Sons.

Wibisono, D. (2013). *Panduan penyusunan skripsi* (Doctoral dissertation, Tesis Dan Disertasi. Jakarta: AndiPublisher).