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TECHNICAL STUDY OF OVERBURDEN EXCAVATION METHODS BASED ON MATERIAL CHARACTERISTICS AT PT KALTIM PRIMA COAL

KAJIAN TEKNIS METODE PENGGALIAN OVERBURDEN BERDASARKAN KARAKTERISTIK MATERIAL DI PT KALTIM PRIMA COAL

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ABSTRACT

PT Kaltim Prima Coal is one of the largest companies in Indonesia engaged in coal mining. PT Kaltim Prima Coal aims to achieve an annual production target of 50.5 million tons of coal by 2024. To maintain a high production level, PT Kaltim Prima Coal must select the most appropriate and effective mining method to achieve fleet productivity. For this purpose, a technical study focused on selecting the most suitable overburden excavation method based on the characteristics of the overburden layers is required. The initial step to determine the most suitable method to apply is to use the Franklin Index diagram. Using the Franklin Index diagram requires testing the point load index of the overburden material at Pit X and directly measuring the fracture spacing (scanline fracture spacing) at the research site. Based on the analysis of data and technical studies conducted, overburden layers A, B, C, F, H, and I are recommended to use blasting methods for loosening, overburden layers D and E are recommended to use free excavation methods, and for overburden layers G, J, and K, it is recommended to use double blasting methods for loosening. Observations related to the productivity of excavator units at Pit X revealed an increase in productivity for each unit that initially used the free excavation method and was switched to the blasting method, ranging from 15% to 39% for the Liebherr R996, while a smaller increase occurred for the Hitachi EX3600-6B, which only saw a 3% increase in productivity.

Keywords: excavation method, overburden, free excavation, blasting, digging force

ABSTRAK

PT Kaltim Prima Coal merupakan salah satu perusahaan terbesar di Indonesia yang bergerak di bidang pertambangan batubara. PT Kaltim Prima Coal pada tahun 2024 menargetkan produksi tahunan sebesar 50,5 juta ton batubara, untuk mempertahankan tingkat produksi yang baik PT Kaltim Prima Coal harus memilih metode penggalian yang paling tepat dan efektif untuk mencapai produktivitas armada. Untuk itu diperlukan kajian teknis yang berfokus pada pemilihan metode penggalian lapisan tanah penutup yang paling sesuai dengan karakteristik lapisan tanah penutup penyusunnya. Langkah awal yang dapat dilakukan untuk menentukan metode apa yang paling sesuai untuk diterapkan dengan menggunakan penentuan metode dengan mengacu pada diagram Indeks Franklin. Dengan menggunakan diagram Indeks Franklin diperlukan kegiatan pengujian indeks beban titik material overburden di Pit X dan mengukur jarak antar rekahan secara langsung (scanline fracture spacing) di lokasi penelitian. Hasil analisis data dan kegiatan kajian teknis yang telah dilakukan, overburden A, B, C, F, H, dan I direkomendasikan menggunakan metode peledakan untuk pelonggaran, overburden D dan E direkomendasikan menggunakan metode penggalian bebas, dan untuk overburden G, J, dan K direkomendasikan menggunakan metode peledakan dua kali untuk pelonggaran. Dilakukannya pengamatan terkait produktivitas unit alat gali (excavator) pada pit X, mendapatkan hasil berupa kenaikan produktivitas tiap – tiap unit yang awalnya menggunakan metode penggalian bebas dialihkan menggunakan metode blasting berkisar pada 15% sampai 39% pada Liebherr R996 dan kenaikan yang tidak begitu besar terjadi pada Hitachi EX3600-6B yang hanya mengalami kenaikan produktivitas sebesar 3%.

***Kata kunci**: metode penggalian, overburden, penggalian bebas, peledakan, digging force*

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INTRODUCTION

PT Kaltim Prima Coal is one of the largest companies in Indonesia which operates in the field of coal mining using the open pit method or so-called *open pit*. As one of the largest companies, PT Kaltim Prima Coal has a daily production target that must be achieved. This company must be able to apply new knowledge or ideas at every step of mining activities to maintain efficient production levels. Mining activities at this company consist of land clearing, overburden removal, as well as coal mining.

Overburden separation process is an activity in the mining process which aims to destroy or separate rocks from the parent rock so that it is easy to load [1]. Dispersal activity *overburden* carried out using a loading digging tool with the direct excavation method (free digging) and detonation (blasting). The direct excavation method uses a dig-loading tool, usually for soft materials like topsoil, subsoil and mud, while the scattering method overburden with blasting, done if the material is hard so that the material breaks and will be easier to dig and load into a vessel dump truck [2].

The parameters that must be considered in the selection of overburden excavation methods include the characteristics of the material that makes up the overburden, the condition of the area around the pit and the digging force of the excavation equipment unit [3]. The selection is very necessary in mining activities because it affects the efficiency and effectiveness of overburden excavation activities. Determining the right method will speed up the digging time. If the excavation time of overburden material is faster, the cycle time of the digging and loading equipment will be smaller so that the productivity of the equipment will increase.

The current overburden excavation methods at PT Kaltim Prima Coal are free digging and blasting. The technical study used to determine whether the material in Pit X is excavated by direct excavation or blasting method, the first is by paying attention to the area around the mining. Judging from the direction of mining in Pit X which will continue to lead to the north, where the area is a densely populated area resulting in obstruction of the mining process caused by residents who are in an unsafe radius area for the overburden removal process with the blasting method. The implementation of blasting activities must first evacuate residents to a safer area.

The variable that needs further attention is productivity [4], where in the overburden removal process by free digging is less efficient because the overburden material in Pit X is classified as hard and thick which causes a decrease in productivity, due to the occurrence of bucket nail collection relatively faster. If the excavation equipment works harder, it will require maintenance time that is faster than it should be, resulting in the equipment being in the no location phase [5]. The last aspect that needs to be considered is the blasting process carried out around densely populated areas, where a decrease in the blasting formula is carried out to reduce the impact of the blasting process, resulting in a low powder factor value [5]. Technical studies are needed related to the selection of the most suitable overburden excavation method for Pit X material types located around populated areas, taking into account the characteristics of the overburden constituent materials, as well as the digging force of the loading and unloading equipment units used.

Therefore, this study was conducted to determine the most suitable overburden excavation method based on the characteristics of the overburden material. Prior studies have primarily concentrated on evaluating material properties based solely on the UCS value and the material type within the pit [6]. The objective of this study was to deliberate on alternative factors that should be considered when selecting the most effective and efficient method for excavating overburden with incorporates PLI values and fracture spacing as additional considerations.

RESEARCH METHODS

The research methods carried out in conducting this final project research are as follows:

1. Literature Study
   Literature study is useful in finding reference data that becomes a reference in supporting the implementation of research. Reference data obtained from literature studies are sourced from related agencies, journals, books and internet media related to overburden removal activity methods, digging time, digging force and productivity of excavating and loading equipment.
2. Field Observation
   Observation activities are carried out to directly observe the problems that occur in the field related to the research to be carried out. This activity was carried out by observing the implementation of overburden excavation activities, as well as the cycle time required by the excavating equipment to dig overburden. In addition, scanline activities were also carried out to observe the fracture size of a field.
3. Data retrieval
   Data collection is carried out in order to obtain data that will be processed to solve the problems of the research. The data obtained consists of two types, namely:
   a. Primary Data
      Primary data is data obtained based on measurements taken directly in the field. Primary data needed in this study include:
      1) Observation Area Documentation
         Documentation of overburden excavation activities using free digging and blasting methods was taken using a mobile phone camera. Documentation was taken during

Jurnal Pertambangan
http://ejournal.ft.unsri.ac.id/index.php/JP
Jurnal Pertambangan Vol. 9 No. 1 Februari 2025
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direct excavation, and when excavation was carried out in the post-blasting area.

2) Cycle time of Loading and Digging Equipment
The cycle time of the digging and loading equipment is obtained from measurements using observations through the mine dispatch system (fleet management system) for one month so that the cycle time and effective working hour of each digging and loading equipment in Pit X are obtained.

3) Fracture Spacing
Fracture spacing was obtained from direct observations and measurements in the high wall, low wall and side wall areas in Pit X.

b. Secondary Data
Secondary data is data obtained without taking direct measurements in the field. Secondary data needed in this study include:

1) PT Kaltim Prima Coal Mining Business License Map
2) Field geological data
Geological data obtained from the Geotechnic Department was used to determine the type of material at the excavation site. The data is borehole data obtained from the full coring drilling process. The required data include Uniaxial Compressive Strength (UCS) and Point Load Index (PLI) data in Pit X area of PT Kaltim Prima Coal.
3) Specification of Digging and Loading Unit
The specifications of the digging and loading equipment are used as a reference for the fill factor and bucket capacity listed in the spec book of each unit used.

4. Data processing
Data processing was done with Microsoft Excel 2013 software. The stages of data processing in this study are as follows:
a. Calculating the average Point Load Index (PLI) of overburden layers. This calculation is obtained from secondary data that has been obtained from each coal overburden layer.
b. Calculate the average fracture spacing of each overburden layer that has different material types.
c. Calculate the productivity of each fleet of excavation equipment in Pit X by considering the work efficiency of the equipment and the characteristics of the overburden layer material.

RESULTS AND DISCUSSION

Point Load Index

PLI testing is a compressive test on a material at one point, so that from this test we will get advice on what method is most appropriate in overburden excavation activities [7]. Based on the results of laboratory tests that have been carried out, for sandstone and mudstone rocks that will be tested are from each overburden and from each elevation of the overburden (referring to the LOM design) so that the PLI value is obtained in Table 1.

Table 1. Test Results *Point Load Index* Material Pit X

OVERBURDEN	PLI (MPa)	ELEVATION (masl)	
		From	To
Seam A	0,24	16,92	5,22
Seam A	0,26	4,42	-24,45
Seam B	0,44	17,10	0,10
Seam B	0,19	-0,58	-28,58
Seam C	0,17	17,10	-3,58
Seam C	0,21	-5,80	-28,58
Seam C	0,55	-33,38	-51,05
Seam D	0,24	16,70	-8,01
Seam D	0,24	-12,13	-38,07
Seam E	0,51	18,54	-5,04
Seam E	0,43	-8,66	-35,87

Fracture Spacing

Determining recommendations for overburden excavation methods that are in accordance with the characteristics of the material and supported by the use of the Franklin Index requires data related to the distance between bridles (Fracture Spacing) [8]. In this study, fracture spacing data was obtained by direct measurement on the active slope area which will later become the direction of the mine progress, and the results of direct measurement (scanline) in the field (Table 2).

Table 2. Measurement results *Fracture Spacing* at Pit X

OVERBURDEN	FRACTURE SPACING (m)	ELEVATION (masl)	
		FROM	TO
Seam A	0,98	16,92	5,22
Seam A	0,70	4,42	-24,45
Seam B	0,55	17,1	0,1
Seam B	0,82	-0,58	-28,58
Seam C	0,59	17,1	-3,58
Seam C	1,10	-5,8	-28,58
Seam C	1,55	-33,38	-51,05
Seam D	1,23	16,7	-8,01

Franklin Index Criteria

In this research, data collection related to the value of point load index testing and fracture spacing measurements focused on Pit X PT Kaltim Prima Coal [9]. The results of tests and measurements that have been carried out directly produce data that can be input into the Franklin Index diagram, and the results of the adjustment between the data of the point load index test results and

Jurnal Pertambangan
http://ejournal.ft.unsri.ac.id/index.php/JP
Jurnal Pertambangan Vol. 9 No. 1 Februari 2025
ISSN 2549-1008

the data of the fracture spacing measurement results obtained recommendations for overburden excavation methods for Pit X as shown in Figure 1 [10].

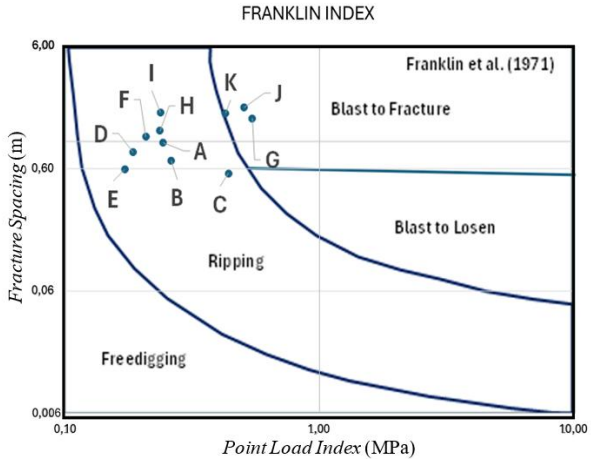

Figure 1. Results *Plotting* Data on the Franklin Diagram

From the plotting results (Figure 1), the recommended overburden removal method is blast to fracture. However, because pit X is directly adjacent to a resident's house that has a foundation made of wood, the blast to fracture method will be changed to the 2x blast to loosen method. This is because the foundations of the surrounding houses are not very strong and a reduction in the use of explosives is required, which causes a low powder factor value to be used. Overburden that is recommended to use the ripping method will be transferred to the use of free digging and blast to loosen methods. The absence of the use of ripping method at PT Kaltim Prima Coal is due to the limited capability of ripping tools that will not be able to keep up with the productivity of the digger used.

Table 3. Recommendations for Excavation Methods and Tools in Pit

CODE	*OVER BURDEN*	METHOD RECOMMEN-DATIONS	DIGGER RECOMMEN-DATIONS
A	Seam A	Blast to lose	Hitachi EX3600
B	Seam A	Blast to lose	Hitachi EX3600
C	Seam B	Blast to lose	Hitachi EX3600
D	Seam B	Free Digging	Liebherr R996
E	Seam C	Free Digging	Liebherr R996
F	Seam C	Free Digging	Liebherr R996
G	Seam C	Blast to Fracture (2x Blast to Loosen)	Liebherr R996
H	Seam D	Blast to Lose	Hitachi EX3600
I	Seam D	Blast to Lose	Hitachi EX3600
J	Seam E	Blast to Fracture (2x Blast to Loosen)	Liebherr R996
K	Seam E	Blast to Fracture (2x Blast to Loosen)	Liebherr R996

Digging force needs to be adjusted to the characteristics of the material to be excavated later. In Pit X using 3 types of excavators used include Hitachi EX3600-6 with a digging force value of 1,050 kN, Liebherr R996 has a digging force value of 1,535 kN, considering the digging force value the tool will not be able to provide the same treatment on different material characteristics [5].

Based on Table 3, areas where the main material is mudstone cause the value of fracture spacing to be large. This is because mudstone material has a higher rock strength so there are few braces. Sandstone material is usually scattered, so there are usually more braces in the material. Therefore, the greater the fracture spacing and point load index of the rock, the tool that has a high digging force is needed to excavate the overburden and vice versa if the fracture spacing and point load index are small, a tool with a lower digging force can be used.

Excavator Productivity

After the material characteristics are known from the results of point load index testing conducted in the laboratory and direct measurements related to fracture spacing, the value is entered into the Franklin Index diagram. From the studies that have been carried out, direct trials will be carried out in Pit X regarding the productivity of overburden excavation.

Table 4. Productivity *Excavator* at Pit X

Unit Excavator	AREA	*Overburden*	Cycle Time (s)	Excavator Productivity (BCM/Jam)
Hitachi EX 3600-6B	Live Digging	Seam A	47	1.074,26
		Seam B	52	967,08
		Seam C	53	1.054,26
Liebherr R996B	Live Digging	Seam A	54	1.530,00
Liebherr R996S	Live Digging	Seam A	53	1.472,26
		Seam B	50	1.381,65
		Seam C	55	1.418,73
Hitachi EX 3600-6B	Post Explosion	Seam A	41	1.108,32
		Seam B	38	1.328,68
		Seam C	40	1.396,89
Liebherr R996B	Post Explosion	Seam A	43	2.126,34
Liebherr R996S	Post Explosion	Seam A	46	1.696,30
		Seam B	47	1.660,21
		Seam C	45	1.734,00

From the productivity observations in Table 4, which have been made in the area using the direct excavation method and the post-blasting area, a graph is produced as shown in Figure 2. The equipment working in overburden seam A has an increase in productivity when applying the blasting method, where for the Hitachi EX3600-6B unit has an increase in productivity of 3%, the Liebherr R996S unit has an increase in productivity of 15%, and the Liebherr R996B unit has the largest productivity increase of 39%.

Jurnal Pertambangan
http://ejournal.ft.unsri.ac.id/index.php/JP
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ISSN 2549-1008

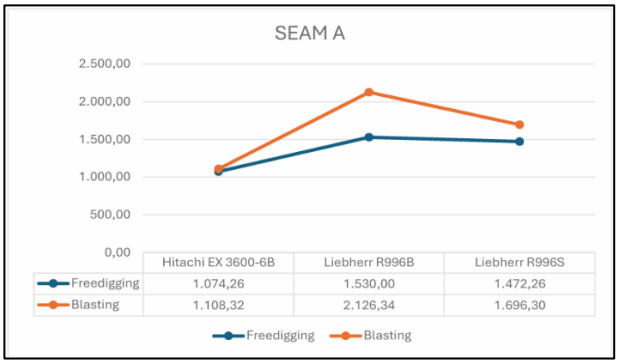

Figure 2. Productivity Comparison Chart on *Seam* A

Based on observations of the productivity of the excavating equipment working in the overburden excavation of seam B (Figure 3). In the Hitachi EX3600-6B unit, the productivity of the equipment has increased quite high, which is 43% compared to the productivity when working with the direct excavation method. In the Liebherr R996S unit, the productivity of the tool also increased from the productivity results when using the free excavation method by 25%, and in the Liebherr R996B unit did not operate because there was no area that had been blasted so there was no material that could be excavated by the tool.

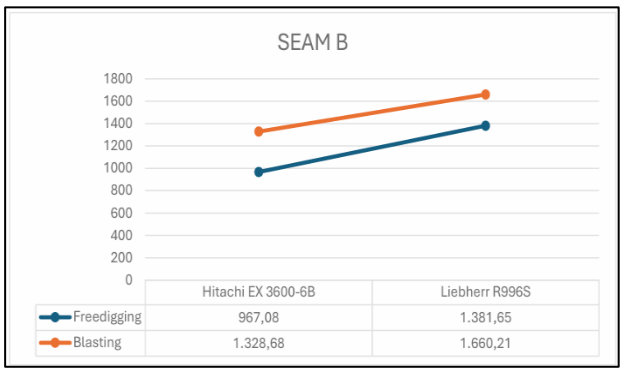

Figure 3. Productivity Comparison Chart on *Seam* B

Based on observations of the productivity of the excavation equipment working in the overburden excavation of seam C, the productivity comparison graph shows a high increase in almost every tool (Figure 4). The Hitachi EX3600-6B unit experienced an increase in productivity when used in an area that had been blasted, the increase in productivity was 35%, and for the Liebherr R996S unit experienced an increase in productivity as well, when compared to productivity when digging directly, the productivity of this tool increased by 24%, while the Liebherr R996B unit did not carry out mining operations using direct excavation or blasting methods.

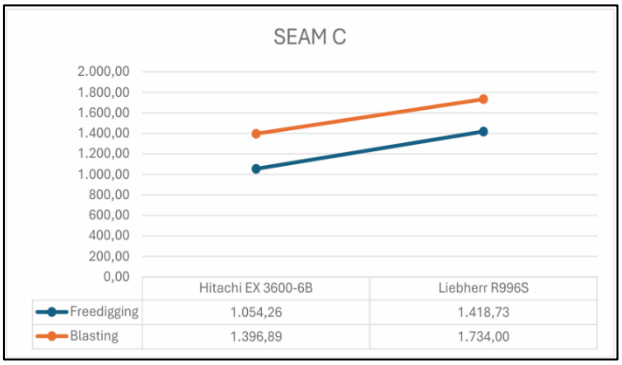

Figure 4. Productivity Comparison Chart on *Seam* C

CONCLUSION

With the main constituent material of overburden in the form of mudstone and sandstone which has an average Point load value of 0.31 MPa and has an average fracture spacing value of 1.17 meters, determining the appropriate excavation method must look at the digging force of the digging and loading equipment used. Where for the Hitachi EX3600-B, Liebherr R996B, and Liebherr R996S units using the free digging method by producing productivity of 1,031.87 BCM/hour, 1,530 BCM/hour, and 1,424.21 BCM/hour. And for units that are directed to use the blasting method are the Hitachi EX3600-S, Liebherr R996B, and Liebherr R996S units with productivity of 1,277.96 BCM/hour, 2,126.34 BCM/hour, 1,696.84 BCM/hour. The determination of the most suitable method has been carried out, the comparison of the increase in productivity from the previous Hitachi EX3600 in overburden seam A is 3% while the increase in productivity of Hitachi EX3600, Liebherr R996S and Liebherr R996B in other overburden has a fairly good increase of 15%-39%.

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