OPTIMISATION OF BROKEN RECOVERY IN THE JAGUAR PIT PANEL OF THE SOUTH DEPARTMENT OF JUPITER AT PT KALTIM PRIMA COAL

A.D. Can[1], Bochori[1], R. Pebrianto[1]

[1]Teknik Pertambangan, Universitas Sriwijaya, Palembang
[*]*Corresponding author* e-mail: rosihanpebrianto@ft.unsri.ac.id

ABSTRACT: PT Kaltim Prima Coal (KPC) is one of the largest coal mining companies in Indonesia, operating in East Kutai, East Kalimantan. One of its operational areas, the Jaguar Panel in Pit Pinang South, was selected as the focus of this study with the main objective of optimizing broken recovery, defined as the percentage of blasted material successfully hauled. Based on field data from January–February 2025, the broken recovery rate was only 86% of the total blasted volume of 798,980 bcm, leaving 112,065 bcm of broken left material. The study employed Root Cause Analysis, Why-Why Analysis, and Priority Matrix to identify the main factors and determine corrective actions. The results indicated that a mismatch between blast hole depth and the optimum digging height of the Liebherr R996 excavator (4.2 m/pass) was the dominant cause of low recovery. The solution implemented was the 812 system, a combination of 8 m and 12 m blast hole depths adjusted to field elevation. After applying the 812 system, the broken recovery rate increased significantly to 95.8%, along with improvements in digging rate, excavation time, and overall excavator productivity. This study concludes that the 812 system is an effective and efficient technical strategy to enhance operational efficiency without modifying burden, spacing, or powder factor.

Keywords: Broken recovery, blasting, digging rate, system 812

1 Intorduction

Coal mining activities consist of drilling, blasting, loading, and transportation stages. Blasting is a method of rock removal commonly used in open pit mines to facilitate the excavation process, although it can cause negative impacts such as flyrock, ground vibrations, and noise [1]. The effectiveness of the blasting design greatly affects the success of the subsequent stages, especially the loading and transportation processes [2]. The right design will produce a bench geometry that matches the optimum capacity of the loading equipment, while an inappropriate design can lead to an increase in the amount of material left behind as broken left [3].

One parameter used to assess the success of blasting activities is broken recovery, which is the ratio between the amount of blasted material that is successfully transported and the total volume of blasted material [4]. A low broken recovery value indicates that there is still unmined material, which reduces production efficiency [5].

In practice, there are issues that often arise related to low broken recovery, including the incompatibility of the drill hole depth with the optimum digging capacity of the loading equipment, the condition of the bench after blasting, and the cycle time and digging rate of the loading equipment [6]. These factors are interrelated and need to be identified so as not to cause a decrease in productivity in loading and transportation activities [7].

Previous studies have shown that fragmentation and bench geometry have a significant effect on the performance of loading equipment. Fajar (2019) [1] found that poor fragmentation can reduce the productivity of loading equipment. Sujiman et al. (2014) [7] stated that the right blasting geometry parameters play an important role in improving the fragmentation of blasting results. Sadiq (2021) [6] reported that the application of the bottom air deck technique and an expanded blasting pattern can optimize the use of explosives while improving blasting results. In addition, classic studies by Konya & Walter (1990) [8] and Jimeno (1995) [9] emphasize the importance of blast design that considers rock mass conditions to produce benches that can be excavated efficiently.

Based on this description, this study aims to: (1) determine the initial broken recovery conditions at the Jaguar Panel, Pinang South Pit, PT Kaltim Prima Coal, (2) analyze the causes of low recovery values using the Root Cause Analysis, Why-Why Analysis, and Priority Matrix methods, and (3) formulate technical solutions in the form of implementing the 812 system, which adjusts the depth of the drill hole to field conditions.

The hypothesis in this study is that the application of the 812 system can increase the broken recovery value while improving the digging rate and digging time of the Liebherr R996 loading excavator. Thus, this study is expected to contribute to the company in increasing production efficiency and serve as a reference for further research in the field of blasting and excavation optimization [10].

2 Research Method

This research was conducted at the Jaguar Panel, Pit Pinang South, PT Kaltim Prima Coal, located in Sangatta, East Kalimantan. This location is one of the company's active pits that focuses on overburden removal and coal excavation using an open pit mining system. The Jaguar Panel was chosen as the research location because this area has a broken recovery problem, with values still below the company's target. This condition indicates that there is blasted material that is not loaded into the transport equipment, which has the potential to reduce mining production efficiency. The field research was conducted from February 17 to May 23, 2025, and included field observations, direct measurements, recording of operational data, and collection of secondary data from the company.

A literature study was conducted by reviewing various references relevant to the research material, including books, scientific journals, and other reliable sources. Field observations were carried out through direct observation of the actual conditions of mining activities related to the formulation of the research problem. The data used in this study consisted of two categories, namely primary data and secondary data.

Primary data was obtained directly from the field through observations at the research site and was compiled systematically. In this study, primary data included measuring the loading equipment excavation time using a digital stopwatch for 30 cycles after implementing the 812 system, as well as documenting the actual height at the beginning and end of the excavation phase to evaluate the suitability of the blast hole depth with the optimal excavation height of the Liebherr R996 loading equipment.

Secondary data is supporting data obtained from PT Bukit Asam Tbk. This data includes the technical specifications of the Liebherr R996 loader and Sandvik D55SP drill, blasting results data in the form of total blasting volume and remaining unbroken volume obtained from the Drilling and Blasting Department of PT KPC, and loader productivity data compiled from the company's production monitoring system

2.1 Data Processing

Data processing is carried out by combining theory with data obtained from the field. The stages of data processing are as follows:

2.4.1 Data Processing and Analysis

(1) Data will be collected directly at the research site, namely the Jaguar Pit Pinang South Panel, using technical observation and documentation of overburden excavation activities.
(2) Digging time data will be collected and then calculated for 30 data points for each Liebherr unit (Liebherr 5, 13, and 19) located in the Jaguar Panel to determine the average per excavation cycle, where the predetermined excavation target is 13 seconds per cycle.
(3) Excavation height data was obtained in the form of visual documentation in the field, which was then processed using a tracker application.
(4) Broken recovery that did not reach the target was analyzed to determine the root cause of the problem after all data was collected and processed. The root cause analysis approach was used at this stage by grouping the problems into four main aspects, namely material, method, manpower, and environment. Several factors contributing to high broken left include hard rock, lack of attention to excavation references, etc.
(5) Each identified cause is analyzed in depth using the why-why method to obtain the main root cause. The analysis results show that the mismatch between the depth of the blast hole and the optimal excavation capacity of the Liebherr R996 equipment is the dominant factor. This difference

causes most of the remaining material to remain unexcavated and become broken left.

(6) The broken recovery value will be analyzed by comparing the conditions before and after the implementation of the improvement solution, particularly in relation to the blast design adjustments applied in the field. The calculation will focus on the volume of broken material that was successfully removed and the volume of broken left material that remains, so that the effectiveness of the design changes in improving the fragmentation quality and productivity of the excavation activities can be determined.

(7) The collected digging time data will be used to calculate the digging rate and productivity of the excavator unit, so that the actual capacity of the equipment in moving material can be determined. This analysis provides an overview of the volume of material that can be moved within a certain period of time, while also assessing whether the performance of the excavator is optimal according to the established plan. In addition, the results of the analysis can be used as a basis for evaluating the factors that affect the efficiency of the equipment and the potential improvements that can be made.

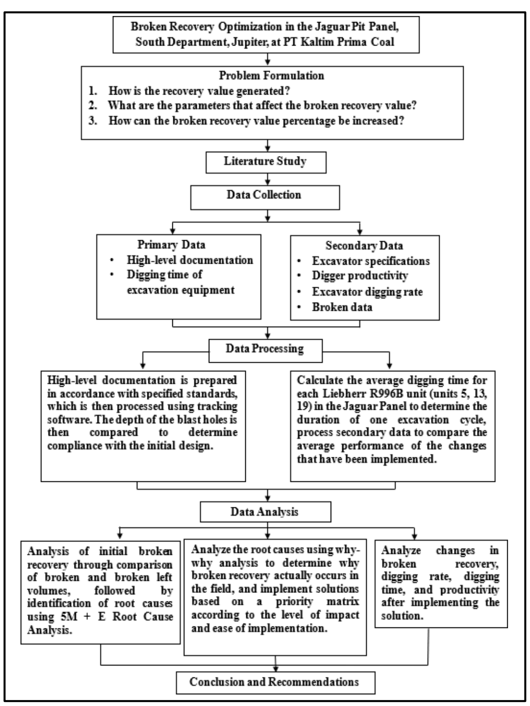


Figure 1. Research Flow Chart

3 Results and Discussion

3.1 Blasting Process at Pit Pinang South, PT Kaltim Prima Coal

3.1.1 Drilling Process

Before drilling activities are carried out, preparations must be made at the drilling site. The preparations include determining the drilling points in accordance with the blasting plan (Figure 2), ensuring that the site boundaries are marked by windrows, that the drilling surface is level, that there is no standing water, that drainage is adequate, that the terrace width is at least 14 metres, a vehicle parking area, no hanging rocks near the location, no piles near the crest so that drilling can be carried out, survey stakes and drilling reference limits must be installed, and there must be a light vehicle parking area. Once all criteria are met, the Customer Supply Agreement (CSA) documents are handed over, signifying that the location is ready for drilling.

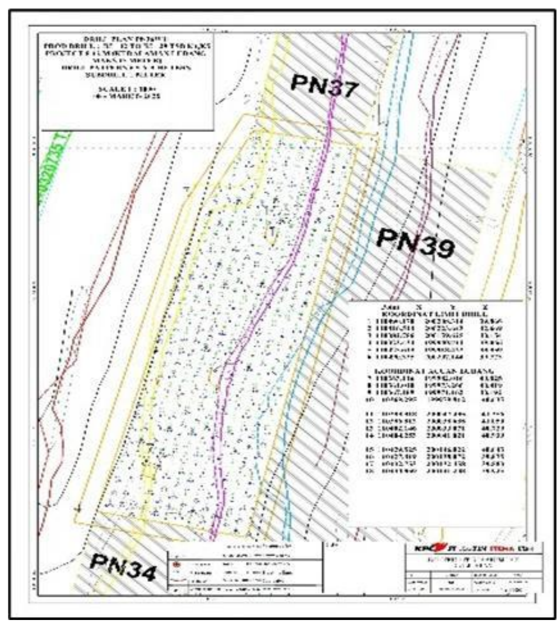


Figure 2. Drill plan design

The drilling rig used in drilling operations at Pit Pinang South is the Sandvik D55SP (Figure 3). The D55SP drilling rig uses a 200 mm diameter tricone bit and is capable of reaching a maximum hole depth of 31.9 m. This equipment is designed to work in varying geological conditions, providing stable and precise drilling performance. In addition, the Sandvik D55SP has good operational efficiency, with an average drilling speed of

110 m/hour, thereby supporting the overall productivity of drilling activities. The combination of technical capacity and drilling speed makes this tool ideal for overburden drilling needs at Pit Pinang South.

Figure 3. Sandvik D55SP drilling rig

3.1.2 Blasting Activities

The primary wiring was carried out by PT Orica Mining Services as the blasting contractor. The primary wiring stage included the installation of boosters and detonators as the main elements triggering the explosion. The blasting method used at Pit Pinang South is top decking, which is a technique of filling explosives where part of the explosive column is placed at the bottom of the hole and the other part is placed at the top, separated by stemming material. This method aims to control the distribution of blasting energy at a certain depth so that the resulting fragmentation is more even and the potential for overbreak can be minimized.

Each drill hole is equipped with blasting accessories consisting of a booster, in-hole delay, surface delay, and control delay detonator (Figure 4). All components are installed carefully to prevent damage to the detonator cable and to ensure that each component remains protected from mechanical stress, moisture, and other potential disturbances that could affect the reliability of the blasting. This process is directly supervised by a blasting supervisor, who ensures that each installation complies with the blasting design and follows company operating standards. All stages of installation are also systematically documented as part of the quality control procedure to ensure the consistency and safety of blasting activities. If there are any deviations or damage to components, corrective action is taken before the charging process continues, so that the integrity of the blasting is maintained.

Figure 4. Placement of detonation accessories

PT Kaltim Prima Coal uses a single product from PT Orica Mining Service, namely Fortis Eclipse HD with a density of 1.175 g/cm³ and a VOD (velocity of detonation) of approximately 4,100 m/s. The mixture used consists of a ratio of 55% emulsion and 45% ANFO, making this formulation suitable for filling boreholes in both wet and dry conditions. Filling is carried out using a Mobile Mixing Unit (MMU) that pumps liquid/semi-solid explosives through a special hose into the drill hole (see Figure 5). This procedure is accompanied by safety measures such as hose leak checks, marking of work areas, safe distance controls, and verification of the mixture ratio before filling to ensure energy consistency and reduce the risk of misfire classification. The use of MMUs also speeds up operations and reduces personnel exposure to explosives because the mixing and filling processes are centralized, while routine unit maintenance and operator training are important to ensure system reliability in the field..

Figure 5. Filling blast holes with MMU

After filling the explosives, stemming is carried out. The purpose of stemming is to contain the gas produced by the explosion. PT Kaltim Prima Coal uses drilling cuttings and crushed overburden for stemming material. After filling the explosives, stemming is carried out. The material used for stemming is crushed overburden or aggregate, which is cover soil that has been crushed to a size of 3-4 cm. The crushed material is loaded into stemming trucks and transported to the blasting site. The aggregate is then filled into the blast holes (Figure 6).

Figure 6. Stemming filling

After the blasting is done, the next step is to check the post-blast site (Figure 7). This check is to make sure that all blast holes have exploded as planned and there are no misfires. This checking process is super important to make sure it's safe to work and to see how well the blasting plan worked. Post-blast inspection is carried out with the following steps:

1) Initial visual observation from a safe distance to identify potential hazards such as hanging boulders or unstable material.
2) Inspection of drill holes to ensure that no explosives remain. If a misfire is found, the area is immediately marked with a warning sign and handled according to the misfire handling procedure.
3) Measurement of blasting results, including the level of rock fragmentation, the presence of overbreak or underbreak, and checking the throw distance of the material.
4) Recording of data and documentation as evaluation material for improvements to the next blasting design.

3.2 Initial Conditions of Broken Recovery on the Jaguar Panel

3.2.1 Initial Blast Volume

Based on operational data collected at the Jaguar Pit Pinang South Panel during the period from January to February 2025, the Jaguar Panel showed that the utilization rate of blasted material was not optimal. In some areas, blasted material was not completely picked up by the loading equipment, resulting in broken left material. Data analysis shows that the volume of broken left reached 112,065 bcm (bank cubic meters) out of a total volume of blasted material of 798,980 bcm. This condition resulted in only 686,915 bcm of material being successfully recovered or transported.

3.2.2 Broken Left Distribution

Broken left distribution is commonly found in areas with elevations that do not match the target or are outside the optimal reach of the excavator. This occurs in layers that cannot be effectively reached by the Liebherr R996B heavy equipment, which has an optimal excavation reach of 4.2 meters. Spatially, this broken left is scattered across several points in the Jaguar Panel, indicating a systemic problem in the blasting and excavation process.

With a broken left volume of 112,065 bcm out of a total of 798,980 bcm of blasted material, the initial broken recovery percentage only reached 86%. This figure is below PT KPC's standard, which requires a broken recovery percentage above 90% for large-scale mining activities. Analysis of this recovery efficiency shows significant potential for improvement in the production process.

This indicates that the broken recovery value only reached 86%, which is below the company's target for post-blasting excavation efficiency. Broken recovery is an important parameter that shows the extent to which the results of blasting can be optimally utilized by excavation equipment. The higher the recovery value, the more efficient the blasting and excavation process.

Some initial indications of the causes of low broken recovery at the Jaguar Pit Pinang South Panel based on initial observations in the field include:

1) There is a mismatch between the depth of the blast hole and the optimum excavation height of the excavator used.
2) Environmental factors, such as waterlogging due to rainy weather, which interferes with the quality of drill pad preparation and the accuracy of drilling depth.
3) Lack of operator understanding of the optimum excavation system and lack of visual markers such as elevation stakes and swing arm diggers

Based on preliminary calculations, the accumulated volume of broken left reaching 112,065 bcm reflects a significant level of productivity loss in the material removal process. This amount indicates a large potential for improving operational efficiency if this problem can be minimized, particularly through the optimization of technical parameters in blasting and material excavation activities.

3.2.3 Analysis of the Causes of Low Broken Recovery in Pit Pinang South

Efforts to optimize broken recovery rates on the Jaguar panel were carried out using a systematic approach through root cause analysis using the Why-Why Analysis method and determining solution priorities using a Priority Matrix. This approach was used to find the underlying causes and determine the most effective and efficient corrective actions.

Root cause analysis is a systematic method used to trace the main causes of low broken recovery in the Jaguar Pit Pinang South Panel. This analysis aims to identify factors that directly or indirectly affect the performance of blasted material transportation activities (Figure 8).

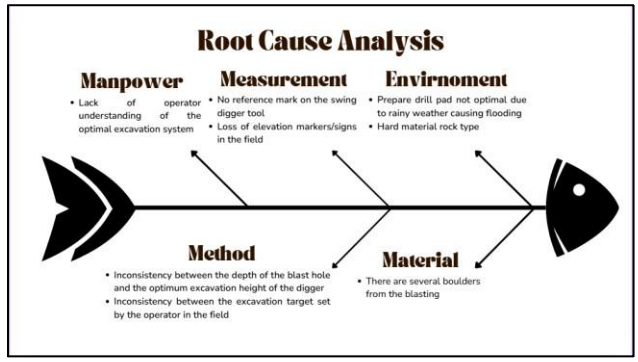


Figure 8. Root Cause Analysis

A Why-Why Analysis was conducted to explore the underlying causes of low broken recovery at the Jaguar Pit Pinang South Panel. This technique was used after conducting a root cause analysis to trace the causes in stages by asking “why” questions for each sub-problem. The purpose of this analysis was to find the fundamental and recurring root causes so that the most appropriate solutions could be determined.

The results of the Why-Why Analysis show that the low broken recovery rate is the result of a combination of technical, operational, and human resource factors that have not been managed synergistically. The problems do not only arise in a single aspect, but are spread evenly across all stages of activities, from drilling preparation to post-blasting excavation. These findings form the basis for prioritizing solutions in the next stage using the Priority Matrix Analysis method.

The results of the why-why analysis produced eight main problems (Table 1) that contributed to the low rate of material recovery. Each problem was then further evaluated using a priority matrix approach, considering two main aspects, namely the level of impact on excavation results and the amount of effort or resources required to make improvements.

Through this process, each root cause was systematically compared to determine its urgency and potential to improve operational performance. This stage also helped identify which issues would provide the greatest benefits if corrected, so that improvement efforts could be focused on the most significant factors. Thus, recommendations for improving excavation efficiency could be formulated in a more targeted, effective manner that was in line with actual conditions in the field..

Table 1. Assessment of sub-problems as the basis for the Priority Matrix

NO	Sub problem	Effort	Impact	Alasan Pemilihan/Tidak Terpilih	Status
1	Ketidaksesuaian kedalaman lubang ledak dengan tinggi jenjang alat gali	1	3	Kedalaman lubang tidak sesuai dengan tinggi jenjang sehingga banyak material tertinggal. Perubahan metode memberikan peningkatan besar pada *broken recovery* dengan usaha relatif rendah.	Terpilih
2	Hilangnya tanda acuan optimum penggalian visual	1	2	Tanda acuan sering tertutup material sehingga operator kesulitan menentukan posisi gali. Pembersihan rutin membuat penggalian lebih tepat meskipun dampak yang dihasilkan tidak besar.	Terpilih
3	Ketidaktahuan operator mengenai hubungan sistem penggalian optimum dengan *broken recovery*	3	3	Potensi dampak tinggi melalui peningkatan kompetensi operator, akan tetapi menghabiskan banyak waktu/biaya/manajemen lebih besar	Terpilih
4	Hilang/tidak terdapatnya patok tanda elevasi pada lapangan	2	1	Melakukan update patok dapat membantu menjaga kesesuaian antara rencana dan kondisi lapangan, tetapi memerlukan tenaga dan koordinasi tambahan.	Terpilih
5	Genangan air pada *drill pad* akibat kondisi cuaca	2	1	Kondisi cuaca sulit dikendalikan sehingga pengaruhnya terhadap *broken recovery* tidak sebesar masalah teknis lain	Tidak terpilih
6	Jenis batuan yang material keras	3	3	Kondisi geologi alami yang sulit diubah, penanganannya membutuhkan biaya dan energi besar sehingga tidak efisien.	Tidak terpilih
7	Terdapatnya beberapa *boulder* dari hasil peledakan	3	3	Membutuhkan pengawasan detail serta biaya yang besar sehingga effort yang dikeluarkan besar	Tidak terpilih
8	Ketidaksesuaian target penggalian di lapangan	2	2	Kurangnya kontrol lapangan memberi pengaruh kecil terhadap *broken recovery* dibanding permasalahan teknis	Tidak terpilih

Of the eight sub-issues identified, only four were included in the priority matrix (Figure 9) because they were considered relevant, significantly influential, and realistic to implement. Quadrant 1, namely adjusting the depth of blast holes according to the optimal level of equipment, was selected as the focus of research because it had the greatest impact on increasing broken recovery with low implementation efforts, through a depth pattern of 8 m at even elevations and 12 m at odd elevations. Meanwhile, quadrant 2 has a small impact, quadrant 3 has a high impact but requires large resources, and quadrant 4 only has a moderate impact. Thus, quadrant 1 is the most appropriate choice because it balances impact and ease of implementation.

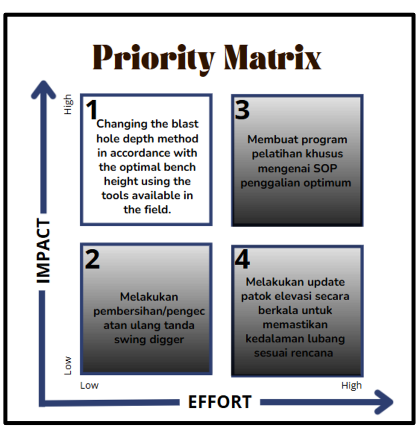


Figure 9. Priority matrix

3.2.4 Broken Recovery Improvement Strategy: Implementation of the 812

The 8/12 system is a method of adjusting the depth of blast holes based on the optimal capacity of the excavation equipment, whereby the Liebherr R996B has an optimal excavation capacity of 4.2 meters per pass. The main objective of this system is to adjust the number of excavation passes to the depth of the blast hole. With an optimal excavation system of 4.2 meters, this will result in 2 excavation passes at a blast hole depth of 8 meters and 3 excavation passes at a blast hole depth of 12 meters (Figure 10). This scheme maximizes the excavator's capacity without leaving any material (broken left), as each excavation stage corresponds to the ideal height of the excavator.

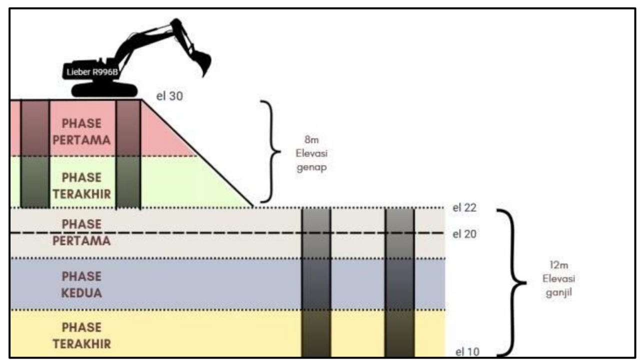


Figure 10. Visualization of the 8/12 system

The implementation of the 8/12 blast hole depth system at the Jaguar Pit Pinang South Panel has shown significant results in improving mining operational efficiency. Measurement and performance evaluation results show a noticeable increase in broken recovery and other operational parameters. Based on the use of a depth of 8/12 (8 meters at the bench elevation and 12 meters at the excavation elevation), there was an increase in broken recovery from 86% to 95.8%.

This increase indicates a 9.8% increase in productivity. This achievement was obtained without making changes to other design parameters such as burden, spacing, or powder factor. This proves that the application of the 8/12 hole depth system is effective in optimizing blasting results and can be used as a reference for blasting activities in the Pit Pinang South area.

Based on the first phase data (Table 2), the highest productivity was achieved in data 3 at 1983.6 bcm/h and the lowest in data 1 at 1651.4 bcm/h. This variation indicates the presence of factors that affect the consistency of excavator performance, such as material conditions, blasting effectiveness, operator skills, and equipment conditions.

Table 2. Results of applying the 8/12 method in the first phase

Phase Pertama	PDTY (bcm/h)	Digtime (s)	Diggrate (bcm/h)	Tinggi penggalian (m)
Data 1	1651,4	16	3458,8	5,1
Data 2	1712,6	14	4185,8	4,7
Data 3	1976,6	16	4131,6	4,5
Data 4	1983,6	14	4007,7	4
Data 5	1925,8	14	3146,1	4
Plan	2000	13	3250	4,2
Average	1850	15	3786	4,4

The average overall productivity in this final phase (Table 3) was recorded at 1893.58 bcm/h with an average digging rate of 2816.3 bcm/h. This data indicates a difference in performance influenced by the working front conditions, excavation reach, and material availability during the area closure stage.

The average overall productivity at this stage was recorded at 1893.58 bcm/h with an average digging rate of 2816.3 bcm/h. This data indicates differences in performance influenced by working front conditions, excavation reach distance, and material availability during the area closure stage.

Comparative performance evaluations between phases are necessary to determine the extent to which changes in field conditions affect operational effectiveness. The aim is to provide an overview of the performance trends of loaders during the observation period.

Table 3. Results of applying the 8/12 method in the final phase

Phase Pertama	PDTY (bcm/h)	Digtime (s)	Diggrate (bcm/h)	Tinggi penggalian (m)
Data 1	1815,5	14	3052,0	3,9
Data 2	1656,7	14,6	1848,8	2,9
Data 3	2043,9	15,9	3172,6	3,6
Data 4	2025,7	14	3991,0	3,5
Data 5	1925,8	14,5	3146,1	3,1
Plan	2000	13	3250	4,2
Average	1893,58	14,62	2816,3	3,4

The digging rate in the final phase showed a downward trend compared to the initial phase (Figure 11). The average digging rate in the final phase was recorded at 2,816.3 bcm/hour, which was below the average value in the initial phase. The lower digging rate performance in the final phase may also be due to the difficulty of digging the material, which requires a longer digging time due to the lack of optimal digging height of the equipment used.

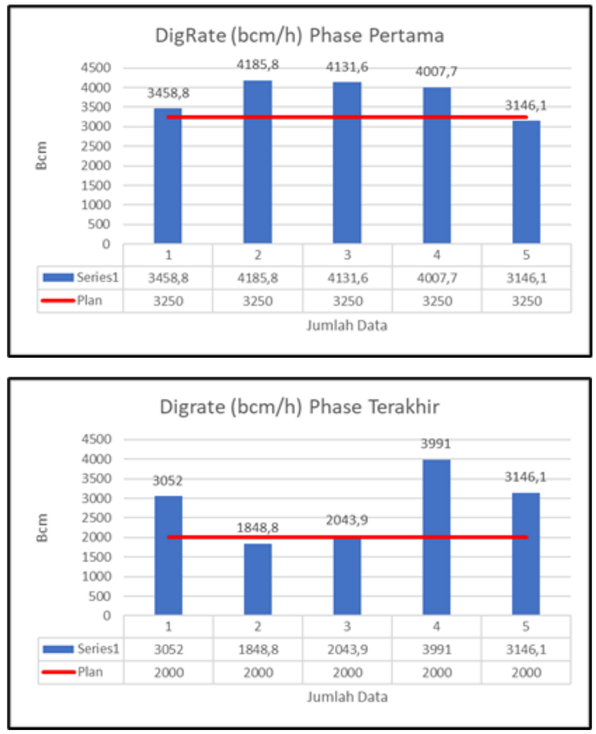
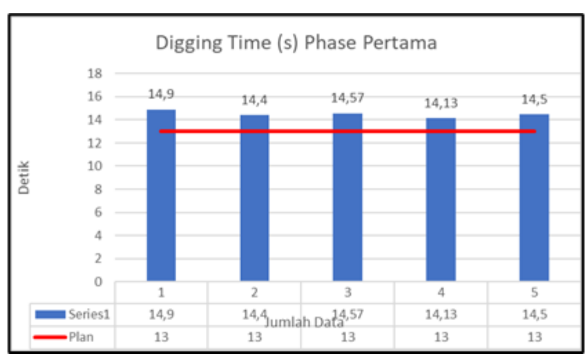


Figure 11. Diggrate comparison graph between phases

A comparison between these two phases shows that although digging time is relatively stable at 14–15 seconds (Figure 12), it has not yet reached the planned time, so a review is needed, whereby the time set is 13 seconds in accordance with the company's SOP..



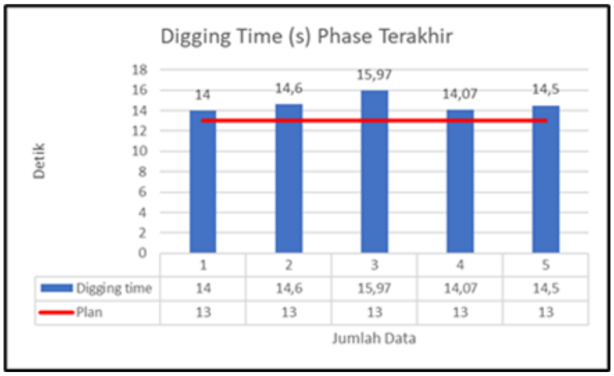


Figure 12. Graph comparing the results of the first and last digging time phases

3.2.5 Comparison of the 8/12 System with Previous Methods

The increase in broken recovery from 86% to 95.8% after implementing the 812 system shows an improvement of 9.8%, which is quantitatively in line with several previous research findings regarding the effect of blasting design adjustments on increasing productivity and excavation efficiency.

The increase in broken recovery from 86% to 95.8% shows a 9.8% increase, which is within the range of efficiency improvements from blasting optimization in previous studies. Fajar (2019) noted that increased fragmentation increased the productivity of digging tools by 8–12%, while Sujiman et al. (2014) reported a reduction in boulders that resulted in an increase in the digging rate of 6–10%. Sadiq (2021) also noted a 10.4% increase in blasting effectiveness through design adjustments.

The results of this study are in line with these findings and even show superiority because the 9.8% increase was achieved without changing the burden, spacing, or powder factor, but only through adjustments to the blast hole depth (812 system), thus quantitatively confirming the effectiveness of this method (Table 4). The implementation process of this system faces several challenges that need to be considered in order to be optimally implemented in the field, such as consistency in measuring drilling depth, controlling hole deviation, and coordination between the drilling and blasting teams. In addition, continuous monitoring is needed to evaluate the effectiveness of the application and design adjustments in accordance with local geological and geotechnical conditions..

Table 4. Comparison of the 8/12 system with the previous system

Before	Average	
Month	*Diggrate*	*Productivity*
Januari	3.617	1.939
Februari	3.456	1.775
Plan	3.250	2.000
Average	3.537	1.857

After (8/12)	Average	
Month	*Diggrate*	*Productivity*
March	3.829	1.961
April	3.837	1.896
Plan	3.250	2.000
Average	3.833	1.928

4 Conclusion and Recommendations

(1) The total volume of material blasted at the Jaguar Panel, Pit Pinang South, was 798,980 bcm.
(2) Of this total volume, only 686,915 bcm was successfully transported, while 112,065 bcm remained as broken left. The initial broken recovery rate was only 86%, which was lower than the company's target.
(3) The dominant factors causing the low broken recovery rate include the mismatch between the depth of the blast holes and the optimum bench height in the field, the operators' lack of understanding of the optimum excavation system for the equipment used, the mismatch between the excavation targets set in the field and the loss of the optimum excavation reference marks on the equipment used in the field.
(4) With the 8/12 system, the total material from blasting reached 2,226,381 bcm, and the material that was successfully transported was 2,132,869 bcm, so that the broken recovery value increased to 95.8% with only 4.2% broken left.

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