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Article

Operational Performance Analysis of the Vertical Retaining Wall Wharf at the Public Port Owned by PT. Pelabuhan Indonesia (PELINDO) Gresik

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ABSTRACT

The Public Port of PELINDO Gresik is one of the strategic ports in East Java that functions as a major hub for regional cargo and logistics movement. Talud Tegak Wharf is one of the operational facilities that plays an important role in supporting cargo handling activities, particularly log timber commodities. This study aims to analyze the operational performance of Talud Tegak Wharf in supporting the smooth provision of port services. This research was conducted at Talud Tegak Wharf of the Public Port owned by PT Pelabuhan Indonesia (PELINDO) Gresik over a one-year observation period. The research employed a quantitative method using an operational performance analysis approach. Data were obtained through field observations and port operational records, analyzed then based on operational performance indicators, including vessel arrival trends, berthing time, cargo handling productivity, and berth utilization rate or Berth Occupancy Ratio (BOR). The analysis results were subsequently compared with port operational performance standards specified in the technical regulations of the Directorate General of Sea Transportation. The results indicate that the operational performance of Talud Tegak Wharf is in a good category. The average productivity of log timber cargo handling reached 63.52 m^3/hour, exceeding the minimum operational performance standard. Meanwhile, the average BOR value of 82.04 percent indicates a high level of berth utilization while still remaining within safe limits. Overall, the analyzed operational performance indicators demonstrate that Talud Tegak Wharf has met the applicable port operational service performance standards at the Public Port of PELINDO Gresik

1. Introduction

Ports are important hubs in driving a country's economy, functioning as connectors for the flow of goods, passengers, and logistics both domestically and internationally (Tri Mulyono, 2019). As a support for activities, ports are inseparable from supporting facilities that are closely related to each other in order to support the operational activities of a port. One of the supporting facilities and the center of activity at a port is the wharf. A wharf that operates optimally and effectively will be a benchmark for port performance because it can facilitate the flow of goods, reduce logistics costs, and increase the competitiveness of industry and trade in the surrounding area (Firdausy, 2021). Pelindo Gresik Public Port is one of the strategic ports located in East Java and serves various types of cargo, ranging from liquid bulk, dry bulk, general cargo, to logs.

Among the many wharf facilities owned by Pelindo Gresik Public Port that are designated according to their specific types, there is one wharf that is the focus of this study, namely the Vertical Retaining Wall Wharf. The Talud Tegak Wharf has characteristics that allow medium-sized ships to dock directly, making it vital in supporting the smooth operation of the port. The specifications of the Vertical Retaining Wall Wharf are also specifically designed for loading and unloading bulk goods and logs as the main commodities in its activities. In this study, the researcher will focus on discussing the main commodity of the Vertical Retaining Wall Wharf, namely logs.

Operational performance at a wharf is rarely stable because utilization fluctuates with vessel-call patterns, the availability and reliability of cargo-handling equipment, weather disruptions, stevedoring labor supply, and operational policies set by the port authority. At Vertical Retaining Wall Wharf, these fluctuations have recently translated into measurable operational problems, including vessel queues during peak call periods, longer berthing and waiting times than planned, and cargo-handling productivity that falls below target on certain days/shifts. These conditions have also triggered service-level concerns raised by users, reflected in complaints regarding schedule uncertainty and increased turnaround time.

This study is therefore urgent because it addresses a clear gap between expected service performance (target productivity and planned vessel turnaround) and actual performance outcomes observed at Vertical Retaining Wall Wharf, where variability in utilization is already producing congestion risk, inefficiencies, and reduced reliability in berth service.

Therefore, this study aims to conduct a performance analysis to evaluate the operational performance of the Vertical Retaining Wall Wharf on a continuous basis over a specific period of time. This research enables the researcher to identify development patterns, trends, and operational dynamics occurring at the Talud Tegak Wharf over the observed period, rather than providing only a snapshot assessment. Through this study, it is expected to determine the extent to which the Vertical Retaining Wall Wharf meets the operational performance standards of the public port of Pelindo Gresik.

Based on these considerations, this study is important because its results not only provide an objective overview of the actual conditions at the Vertical Retaining Wall Wharf, but are also expected to be useful for the management of Pelindo Gresik in formulating improvement strategies, enhancing service efficiency, and optimizing the utilization of facilities at the Public Port of Pelindo Gresik as one of the national economic nodes. Based on this, the author raised a research topic entitled "operational performance analysis of vertical retaining wall wharf at the public port owned by pt. pelabuhan indonesia (pelindo) gresik".

2. Literature Review

2.1 Operational Data-Driven Trend Analysis.

Data-driven trend analysis is a method used to track patterns of change in a variable over a period of time, relying on accurate and measurable historical data. According to Pandrianto (2023), trend analysis is a statistical technique used to study the direction of data development through time series observations. The goal is to determine whether the data exhibits an upward trend, downward trend, or fluctuation, thus enabling researchers to draw conclusions that accurately reflect the dynamics of a phenomenon. One point time.

In a data-driven approach, trend analysis focuses not only on the final results but also on

the process of collecting, processing, and interpreting data. The data used must come from reliable sources, be consistent over time, and have the same units of measurement to allow for objective comparisons. The analysis process is typically conducted using statistical methods such as *moving averages*, linear regression, or time series analysis to identify patterns of change and reduce the effects of random fluctuations in the data.

2.2 Port Operational Performance

Port operational performance is a key indicator in assessing the effectiveness of port services, particularly in facilitating the smooth flow of goods and ships. This performance is not solely related to the number of ships served, but also encompasses efficiency. use time, use facility lean on, and productivity of loading and unloading operations. According to Daniswari (2023), port performance evaluation can be done by measuring waiting time, service time scouting, comparison between time effective and time berthing, and projecting *the Berth Occupancy Ratio* (BOR) as the main benchmark for the effectiveness of dock services. Meanwhile, Anggrahini et al. (2018) emphasized that the total BOR and *Yard Occupancy Ratio* (YOR) significantly affect the level of port operational performance, so facility efficiency must be maintained to prevent overcapacity.

More continued, Kentjana (2023) in his research in Tanjung Perak Port highlights that indicator such as BOR, *Berth Throughput* (BTP), and YOR serve not only as performance measures but also as a basis for planning future port facility development. In line with this, Syayuti et al. (2022) in their study at Tanjung Priok Port stated that the productivity of stevedoring labor, equipment support, and the availability of dock facilities have a positive impact on the port's overall operational performance. Therefore, a comprehensive understanding of port operational performance is crucial not only as a benchmark for the success of port services but also as a basis for decision-making. decision in management and development port in general sustainable.

2.3 Talud Tegak Wharf of Pelindo Gresik

Pelindo Gresik, as one of the public ports managed by PT Pelabuhan Indonesia, plays a strategic role in facilitating the flow of goods, particularly bulk commodities. In terms of operational services, one of the facilities utilized is the Vertical Retaining Wall Wharf. The advantage of the Talud Tegak structure compared to other types of wharves lies in its ability to effectively withstand loads, making it highly suitable for cargo handling activities involving large tonnage.

At the Public Port of Gresik, the Vertical Retaining Wall Wharf is specifically used to support log cargo handling activities, as the characteristics of this commodity require a wharf with adequate structural capacity to withstand the loads imposed by heavy cargo handling equipment, such as harbour cranes or log grapples. In addition, the Vertical Retaining Wall Wharf facilitates direct proximity between vessels and the stacking yard, thereby shortening the cargo distribution route from ship to shore. This is in line with the principles of port operational efficiency, which emphasize minimizing cargo handling time and reducing logistics costs.

The presence of the Vertical Retaining Wall Wharf at the Public Port of Gresik can be reviewed from both technical and managerial aspects. The technical aspects include structural stability (load-bearing capacity against vessel forces, waves, and currents), foundation soil bearing capacity, and material resistance to corrosion due to the marine environment. Meanwhile, the managerial aspects relate to facility utilization (such as the level of wharf usage or BOR), the efficiency of cargo handling processes (vessel productivity and effective working time), as well as the readiness of equipment and labor. An analysis of this wharf is also crucial due to the characteristics of log cargo, which are large in size, non-uniform, and prone to damage, thereby requiring a cargo handling system that is safe, efficient, and measurable.

3. Research Methodology

This research employs a descriptive quantitative method aimed at describing and analyzing the operational performance trends of Vertical Retaining Wall Wharf using available operational data, without manipulating any variables. The research was conducted at the Public Port of Pelindo Gresik, located at Jl. Yos Sudarso No. 1, Gresik, East Java 61114.

3.1 Research period and data range

Field activities and data collection were carried out during the researcher's onshore internship (Praktik Darat) from July 2024 to July 2025, and continued during the seventh and eighth semesters. However, the operational performance dataset analyzed in this study covers a 22-month period, from January 2024 to October 2025, in order to capture performance patterns before, during, and after the internship period and to provide a more representative trend analysis. Accordingly, all descriptive statistics and benchmarking results in Chapters IV and V are based on the January 2024–October 2025 dataset.

3.2 Data sources

Primary data consist of documentation of actual field conditions, as well as operational data recording and processing conducted by the researcher based on predetermined indicators and formulas. Secondary data include port performance standards, applicable regulations and technical guidelines, port operational reports, and supporting literature such as books, scientific journals, and official publications related to port operational performance.

Data collection techniques

Data were collected through documentation, direct observation, and literature review.

Operational definitions and formulas

To ensure clarity and consistency in measurement, the following formulas are applied:

1. Berth Occupancy Ratio (BOR)

$$BOR = \frac{\Sigma BT}{T} \times 100\%$$

Where:

∑BT = total berthing time of all vessels within the analysis period (hours)

BWT = available berth working time within the period (hours)

N = number of berths (if Talud Tegak is treated as one berth, N=1)

2. Berthing Time (BT)

$$BT = t_{berth\ off} - t_{berth\ on}$$

Where:

tberth on = time when vessel is secured alongside (hours or date-time)

tberth off = time when vessel departs the berth (hours or date-time)

3. Productivity (Cargo Handling Productivity)Productivity is calculated depending on the unit used in the port report. Two common operational forms are:

Productivity per hour (Tons per Hour / TPH):

$$Productivity = T : Q$$

Where:

Q = total cargo handled (tons) in the period or per vessel

T = effective working time (hours) (e.g., working hours or net operating hours)

Productivity per gang-hour (if gang data are available):

$$Productivity = G \times H : Q$$

Where:

G = number of gangs

H = working hours per gang

Data analysis techniques

Data analysis consists of two stages: (1) descriptive statistical analysis to describe trends in BOR, productivity, and berthing time over the January 2024–October 2025 period; and (2) benchmarking analysis to compare observed performance values with applicable operational standards and targets set by relevant regulations, technical guidelines, and port performance indicators.

4. Results and Discussion

4.1 Research result

1. Analysis of Vessel Arrival Data

The first indicator analyzed in this research is the trend of vessel arrivals at the Vertical Retaining Wall Wharf during the observation period of 22 months. This indicator is used to observe patterns in the intensity of vessel calls over time and to provide a general overview of the level of wharf utilization. Vessel arrival data are arranged based on monthly call frequency, after which the average value is calculated to assess overall changes in the trend.

Analyzing the trend of vessel arrivals is essential because the number of calls is a primary factor influencing service time allocation, facility utilization, and operational workload within the port area. A higher frequency of vessel arrivals indicates a potential increase in the use of wharf facilities and cargo handling equipment. Conversely, fluctuations or declines in vessel calls may reflect changes in operational conditions, cargo types, market demand, or other external factors.

The following section presents the results of data processing related to the trend of vessel arrivals, using the calculation formulas previously described in Chapter 3. The results are presented in the form of tables and graphs to provide a clearer illustration of vessel movement patterns during the research period.

Table 1 Monthly Vessel Arrival Data at Vertical Retaining Wall Wharf (January 2024 – October 2025)

Bulan	Jumlah Kapal	Perubahan (%)
Jan 2024	6	-
Feb 2024	6	0
Mar 2024	4	-33.33
Apr2024	4	0
Mei 2024	9	+125
Jun 2024	5	-44.44
Jul 2024	5	0
Agu 2024	7	+40
Sep 2024	4	-42.86
Okt2024	5	+25
Nov 2024	5	0
Des 2024	8	+60
Jan 2025	4	-50
Feb 2025	6	+50
Mar 2025	3	-50
Apr 2025	4	+33,33
Mei 2025	4	0
Jun 2025	3	-25
Jul 2025	9	+200
Agu 2025	5	-44,44
Sep 2025	5	0
Okt 2025	7	+40
Total	**118 Kapal**	

Based on the table, it can be seen that the total number of vessels during the period from January 2024 to October 2025 is 118 vessels, with an average of 5.36 vessels berthing per month. To facilitate a clearer interpretation of the calculation results, the researcher also presents a data visualization using a baseline reference from January 2024, which recorded 6 vessels, as shown below:

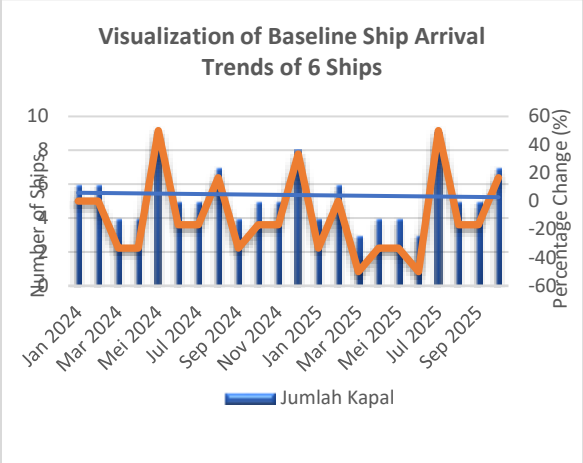

Figure 1 Visualization of Ship Arrival Trend

Based on the table and graph, vessel arrivals at Vertical Retaining Wall Wharf from January 2024 to October 2025 show a fluctuating pattern rather than a consistent upward or downward trend. However, the sharp decline observed in June 2024 cannot be explained only by generic "external factors," because it reflects specific operational and environmental conditions. June marks the beginning of the east monsoon season in Indonesian waters, when stronger winds and higher waves in the Java Sea often disrupt sailing schedules and reduce the number of vessel calls, particularly for certain types of cargo vessels. In addition, mid-year periods are commonly used for preventive maintenance of port facilities or cargo-handling equipment, which may temporarily reduce berth availability and encourage shipping operators to reschedule arrivals. Vessel traffic is also closely linked to commodity distribution cycles; if the wharf handles bulk cargo such as fertilizer, raw materials, or agricultural products, a slowdown in production demand or a post-harvest gap can directly lead to fewer shipments and fewer vessel calls.

Similarly, the increase in April 2025 may be associated with higher cargo movement ahead of major holidays, improved berth readiness, or the clearing of accumulated demand from previous months. Therefore, the observed fluctuations are not random but are influenced by seasonal maritime conditions, cargo cycle patterns, and operational management factors at Pelindo Gresik. This indicates that vessel arrivals at Talud Tegak Wharf are dynamic and

sensitive to both environmental and operational constraints, rather than showing stable linear growth during the observation period.

2. Analysis of Vessel Berthing Time Trend

The trend of vessel berthing time at the Vertical Retaining Wall Wharf serves as an indicator for assessing the efficiency of the berthing process until the vessel departs from the wharf over a research period of 22 months.

This parameter is very important because berthing duration can affect wharf service capacity, queue levels, and the effective utilization of port facilities. The more efficient the berthing time, the more optimal the operational performance of the wharf in facilitating smooth cargo and vessel flows.

Furthermore, trend analysis is conducted based on monthly data from January 2024 to October 2025 to identify patterns of change, fluctuations, and tendencies toward increases or decreases in vessel berthing time. Using the formula previously discussed in Chapter 3, the trend of berthing time at the Talud Tegak Wharf is obtained as follows:

Table 2 Result of Vessel Berthing Time Trend Calculation

Bulan	Total Jam Sandar	Jumlah Kapal	Rata-Rata Jam/Kapal	Perubahan (%)
Jan 2024	486.76	6	81.13	-
Feb 2024	525.17	6	87.53	+7.89
Mar 2024	377.50	4	94.38	+7.82
Apr2024	480.83	4	120.21	+27.37
Mei 2024	806.69	9	89.63	-25.44
Jun 2024	426.83	5	85.37	-4.76
Jul 2024	453.17	5	90.63	+6.17
Agu 2024	682.86	7	97.55	+7.63
Sep 2024	236.48	4	59.12	-39.40
Okt 2024	237.19	5	47.44	-19.76
Nov 2024	502.46	5	100.49	+111.84
Des 2024	816.37	8	102.05	+1.55
Jan 2025	494.58	4	123.64	+21.17
Feb 2025	537.90	6	89.65	-27.49
Mar 2025	304.40	3	101.47	+13.18
Apr 2025	432.66	4	108.16	+6.60
Mei 2025	416.59	4	104.15	-3.71
Jun 2025	290.58	3	96.86	-7.00
Jul 2025	729.54	9	81.06	-16.31
Agu 2025	376.34	5	75.27	-7.15
Sep 2025	397.00	5	79.40	+5.49
Okt 2025	590.32	7	84.33	+6.21
Total	**10.602,22**	**118**	**90,88**	-

Based on the table, it can be seen that the total berthing time during the period from January 2024 to October 2025 is 10,602.22 hours, with a total of 118 vessels. The average time spent by a vessel from the start of berthing until departure is 90.88 hours. To facilitate clearer observation of the calculation results, the researcher also presents a data visualization in the form of a graph using a reference value of 81 hours per vessel, as shown below:

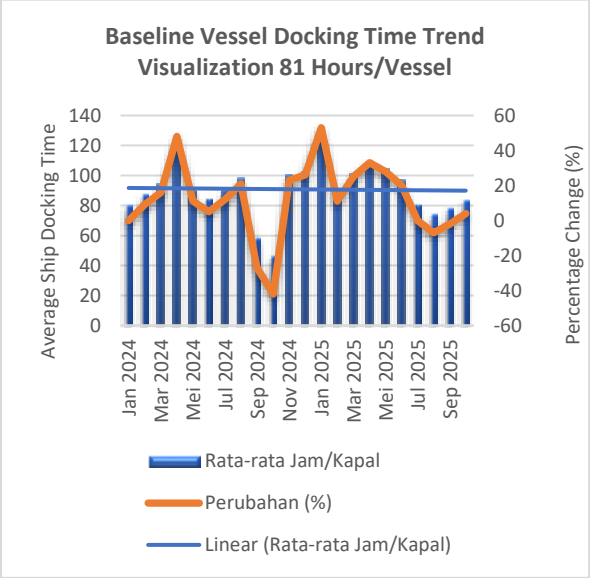

Figure 2 the Average Vessel Berthing Time Trend

Overall, it can be concluded that the trend pattern indicates that berthing time at the Vertical Retaining Wall Wharf has not yet been fully stable. There are still several periods in which efficiency improves, but there are also phases with relatively significant increases. This pattern highlights the need to evaluate the factors contributing to prolonged processes, both in terms of operational activities and equipment readiness, in order to make vessel berthing duration more effective, which in turn can have a positive impact on overall port performance.

3. Cargo Handling Productivity Data Analysis

Cargo handling productivity at the Vertical Retaining Wall Wharf is used to evaluate the effectiveness of cargo handling processes during the research period. This indicator provides an overview of the wharf's ability to complete

loading and unloading activities within a certain time frame, thereby reflecting the level of operational efficiency at the research location. Higher productivity levels indicate more effective cargo movement and more optimal utilization of available facilities.

This productivity analysis is presented to illustrate patterns of change from one period to the next. By observing these productivity movements, the research can demonstrate the performance of cargo handling activities throughout the research period.

As an evaluation reference, cargo handling activities at the Talud Tegak Wharf are based on the performance standards established for the Public Port of Gresik. These standards set a productivity target of 35 tons per gang per hour for the use of GC and BC equipment, and 100 tons per hour for the use of CC and CK. This standard serves as a benchmark to assess whether the actual cargo handling productivity in the field meets the applicable operational targets. With the existence of these standards, productivity measurements for each period can be compared in a more structured and objective manner.

STANDAR KINERJA BONGKAR MUAT BARANG NON PETIKEMAS

NO	NAMA TERMINAL	GC (T/G/J)	BC (T/G/J)	CC (T/J)	CK (T/J)
1	Pelabuhan Umum Gresik	35	35	100	100

Figure 3 Cargo Handling Productivity Standards

To illustrate productivity performance more clearly, this research includes data from the calculation of cargo handling productivity for each period over 22 months, from January 2024 to October 2025. The data are compiled based on the calculation methods previously presented in Chapter 3 and reflect actual field conditions. The results are presented in tabular form to facilitate readability and allow comparison with the applicable performance standards.

Based on the table, it can be seen that the total volume of cargo loaded or unloaded during the period from January 2024 to October 2025 is 354,677 m³, with a total effective time of 6,056.12 hours and an average productivity of 63.52 m³ per hour. The following are the processed data results obtained by the researcher:

Table 3 1of Cargo Handling Productivity Trend Calculation

Bulan	Total Muatan (M^3)	Efective Time (ET)	Rata-Rata Produktivitas (M^3/Jam)	Perubahan (%)
Jan 2024	17.003	323,48	52,56	-
Feb 2024	18.619	401,03	46,43	-11,67
Mar 2024	11.103	265,96	41,75	-10,08
Apr 2024	13.187	346,34	38,08	-8,79
Mei 2024	25.236	564,54	44,70	+17,40
Jun 2024	14.528	321,56	45,18	+1,07
Jul 2024	17.932	321,56	55,77	+23,43
Agu 2024	20.766	404,39	51,35	-7,92
Sep 2024	10.920	179,44	60,86	+18,51
Okt 2024	13.180	170,48	77,31	+27,04
Nov 2024	17.440	327,66	53,23	-31,15
Des 2024	24.211	508,93	47,57	-10,62
Jan 2025	13.460	193,32	69,63	+46,36
Feb 2025	18.270	230,12	79,39	+14,03
Mar 2025	10.167	115,85	87,76	+10,54
Apr 2025	13.285	181,32	73,27	-16,51
Mei 2025	11.414	149,22	76,62	+4,40
Jun 2025	9.838	127,74	77,14	+0,69
Jul 2025	26.771	306,15	87,56	+13,54
Agu 2025	15.448	176,44	87,67	+0,13
Sep 2025	12.706	187,59	67,82	-22,64
Okt 2025	19.193	253,00	75,95	+12,00
Total	**354.677**	**6.056,12**	**63,52**	-

To facilitate clearer observation of the calculation results, the researcher also presents a data visualization using a reference value based on the established performance standard of 35 m³ per hour, as shown below:

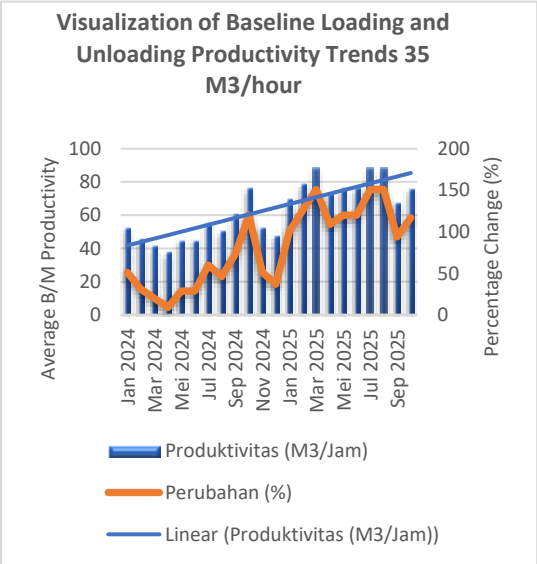

Figure 4 Visualization of Cargo Handling Productivity at the Talud Tegak Wharf

Based on the results of cargo handling productivity calculations from January 2024 to October 2025, productivity values show variations across periods but remain at levels that meet the performance standard of 35 tons

per gang per hour. Several months record relatively clear increases, while other months remain within a relatively stable range. This pattern indicates that cargo handling activities at the Talud Tegak Wharf have been maintained at a good performance level throughout the research period.

When compared with the established operational standards, most productivity achievements are above the reference value. This confirms that cargo handling performance is already at a level that meets the target and should be maintained to remain stable in subsequent periods. Overall, this condition indicates that cargo handling operations have been running effectively and consistently in compliance with the applicable standards.

4. Berth Occupancy Ratio (BOR)

The wharf utilization level, or Berth Occupancy Ratio (BOR), is an indicator used to assess the extent to which wharf capacity is utilized. An increase in BOR indicates a higher level of effectiveness in wharf utilization, while a decrease reflects lower wharf usage during certain periods.

In the context of this research, BOR is analyzed to identify monthly patterns of wharf utilization and to determine whether the utilization level is within an ideal range or experiencing excessive load. Through BOR analysis, the utilization of berthing time and the operational efficiency of the wharf can be observed more clearly, allowing the results to serve as a basis for evaluating performance improvement needs and adjustments to operational capacity at the Talud Tegak Wharf.

STANDAR UTILITAS FASILITAS DAN KESIAPAN OPERASIONAL

NO	NAMA TERMINAL	BOR	SOR	YOR	KESIAPAN ALAT
1	Pelabuhan Umum Gresik	70	-	65	70

Figure 5 Pelindo Gresik Utility Standards

In accordance with the established standards, this research refers to a Berth Occupancy Ratio (BOR) standard of 70 percent. This value is considered the ideal operational threshold, as it reflects efficient wharf utilization without creating excessive congestion risks. A BOR within this range indicates that wharf capacity is optimally utilized while still providing sufficient buffer to maintain smooth vessel traffic. By applying this standard, the BOR calculation results for each period can be compared more systematically to assess whether the level of wharf utilization meets the established performance criteria.

To provide a clearer overview of the utilization level of the Vertical Retaining Wall Wharf, this research includes the results of BOR calculations for each period. The data are presented in tabular form so that monthly changes in BOR values can be systematically observed and compared with the established performance standards:

Table 4 Trend Calculation Result

Bulan	Jumlah Kapal	Total BOR (%)	Rata-Rata BOR (%)	Perubahan (%)
Jan 2024	6	82,62	13,77	-
Feb 2024	6	94,06	15,68	+13,82
Mar 2024	4	63,98	15,99	+1,98
Apr 2024	4	82,37	20,59	+28,82
Mei 2024	9	135,38	15,04	-26,96
Jun 2024	5	73,02	14,60	-2,93
Jul 2024	5	81,64	16,33	+11,84
Agu 2024	7	118,35	16,91	+3,55
Sep 2024	4	41,11	10,28	-39,19
Okt 2024	5	39,18	7,84	-23,74
Nov 2024	5	85,40	17,08	+117,86
Des 2024	8	137,02	17,14	+0,35
Jan 2025	4	81,62	20,41	+19,15
Feb 2025	6	97,89	16,32	-20,07
Mar 2025	3	56,70	18,90	+15,80
Apr 2025	4	73,85	18,46	-2,32
Mei 2025	4	68,95	17,24	-6,61
Jun 2025	3	48,87	16,29	-5,52
Jul 2025	9	122,40	13,60	-16,51
Agu 2025	5	49,19	9,84	-27,65
Sep 2025	5	68,74	13,75	+39,84
Okt 2025	7	102,62	17,10	+24,36
Total	**118**	**1804.96**	**82.04**	-

Based on the table, it can be identified that the total Berth Occupancy Ratio (BOR) for the period from January 2024 to October 2025 amounts to 1,804.96, with a total of 118 vessels and an average BOR of 82.04 percent during the research period. From this average value, it can be concluded that the Vertical Retaining Wall Wharf falls into the category of high activity when compared to the established standard of 70 percent. To facilitate clearer observation of the calculation results, the researcher also presents a data visualization using a reference value of 70 percent, as shown below:

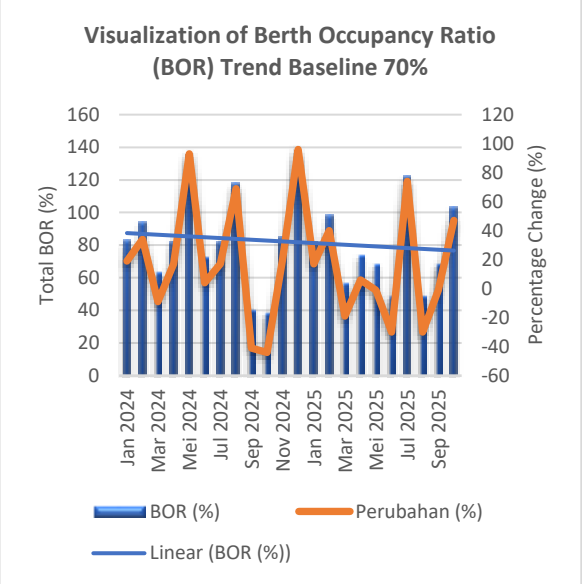

Figure 6 Visualization of the *Berth Occupancy Ratio* (BOR) Trends

Analysis of the Berth Occupancy Ratio (BOR) from January 2024 to October 2025 does not merely show random fluctuation, but indicates periodic clustering of high-utilization months. While the 70 percent utilization standard is used as the ideal threshold, BOR values exceeding this limit are not evenly distributed across the observation period. Instead, they appear concentrated in specific months, notably around December 2024 and July 2025, suggesting a recurring seasonal or demand-driven pattern rather than incidental congestion.

The spike in December 2024 may be associated with year-end shipment acceleration, when exporters and buyers push cargo movements to close annual contracts or meet production targets. In contrast, the elevated BOR observed in July 2025 may correspond to mid-year peak shipment cycles. If Vertical Retaining Wall Wharf predominantly handles log timber or similar bulk commodities, this clustering could reflect production and distribution seasonality. Log timber movements are often influenced by harvesting cycles, weather accessibility in upstream areas, and export demand timing, which can create shipment surges during certain months of the year.

This pattern indicates that congestion is not purely operational inefficiency but is likely linked to seasonal cargo flow dynamics. The recurrence of high BOR in similar calendar periods suggests the presence of seasonality in vessel calls and cargo throughput. Therefore, instead of interpreting high BOR values as isolated congestion events, they should be analyzed as part of a cyclical utilization pattern, which has implications for berth planning, workforce allocation, and equipment readiness during anticipated peak months.

Conversely, there are also months in which BOR values fall below the standard, indicating lower utilization levels. This condition may be caused by a decrease in vessel arrival frequency or operational variations that result in more efficient berthing times, thereby reducing overall wharf usage during those months. Despite the clear differences between highly congested months and relatively less busy periods, the average BOR throughout the research period remains at approximately 82.04 percent, which falls into the category of high utilization while still remaining within a safe operational range.

Discussion

The discussion in this section is structured to address the two research problem statements, namely the fluctuation of operational performance trends at the Vertical Retaining Wall Wharf during the research period and how this performance compares with the applicable operational standards. The discussion analysis is conducted by integrating all calculated performance indicators, including vessel arrival trends, average berthing time trends, cargo handling productivity, and the Berth Occupancy Ratio (BOR).

1. Fluctuations of Operational Performance Trends at the Vertical Retaining Wall Wharf

To address the first research problem, the researcher concludes that the analysis of operational performance indicators shows that activities at the Vertical Retaining Wall Wharf experienced fluctuations during the period from January 2024 to October 2025. This research focuses specifically on a single type of cargo, namely log timber, therefore the observed variations are not caused by changes in commodity types, but rather by the dynamics of vessel arrivals and cargo volumes in each period.

Regarding the vessel arrival frequency indicator, an unstable movement pattern is

observed, in which certain months show an increase in vessel calls, while other months experience a decline. This pattern illustrates that log timber vessel traffic is dynamic and influenced by industrial demand as well as supplier distribution schedules.

The vessel berthing time indicator also shows variation across periods. Although all vessels carry the same type of cargo, differences in cargo volume, field operation speed, and annual technical conditions may cause berthing durations to vary. This indicates that log timber cargo handling operations do not follow a fully consistent handling time pattern throughout the research period.

Cargo handling productivity exhibits fluctuating movements but remains at a generally good performance level. Variations in monthly productivity values are primarily influenced by differences in cargo volume and handling effectiveness during each vessel call.

The Berth Occupancy Ratio (BOR) indicator also demonstrates relatively sharp fluctuations. Several months record very high BOR values, indicating periods of dense wharf utilization, while other months fall below the established standard. These differences reflect the dynamics of vessel arrivals and variations in wharf usage duration, despite the involvement of a single cargo type.

Overall, the discussion addressing the first research problem indicates that the operational performance of the Vertical Retaining Wall Wharf is dynamic, even though all activities involve only one commodity. The observed fluctuations are a reflection of monthly variations in log timber vessel activity, rather than changes in service types or cargo diversity.

2. Comparative Analysis of Vertical Retaining Wall Wharf Operational Performance: Compliance with Port Performance Standards and Alignment with Previous Empirical Studies

To address the second research problem, the researcher concludes that, based on a comparison between the research results and port operational standards, the performance of the Vertical Retaining Wall Wharf is generally in accordance with the applicable regulations. The reference standards used in this research are derived from the Regulation of the Director General of Sea Transportation No. HK.103/2/18/DJPL-16 concerning Port Operational Service Performance Standards. This regulation serves as the basis for evaluating productivity indicators, operational time, and the utilization of wharf facilities.

For the cargo handling productivity indicator, the average productivity of 63.52 m^3 per hour is above the minimum standard of 35 tons per gang per hour. This indicates that log timber cargo handling activities have been carried out effectively and consistently exceeded the established benchmark.

Regarding the Berth Occupancy Ratio (BOR) indicator, the average value of 82.04 percent exceeds the ideal standard of 70 percent and falls into the category of high utilization while remaining within a safe operational range. Although certain months record very high BOR values while others are lower, the overall average remains within a favorable utilization category. This suggests that wharf capacity is used optimally without showing signs of long-term overutilization or underutilization.

Meanwhile, the indicators of berthing time and vessel arrival frequency do not have direct numerical standards specified in the regulation. However, these indicators still provide insight into how wharf operations adapt to variations in log timber cargo volumes and operational demands during each vessel call.

Overall, the analysis results indicate that the operational performance of the Talud Tegak Wharf meets the applicable port operational standards. Productivity and BOR values that exceed the benchmarks set by the Director General Regulation demonstrate that wharf operations are running effectively, and these achievements can be maintained to support the smooth handling of log timber cargo in subsequent periods.

5. Conclusion

Research on the operational performance of the Vertical Retaining Wall Wharf during the period from January 2024 to October 2025 indicates that wharf operations experienced considerable dynamics. The analysis of key indicators such as vessel arrivals, berthing time, cargo handling productivity, and wharf utilization levels reveals movement patterns that are not entirely stable across periods, yet remain within an operationally acceptable range.

Monthly vessel arrivals show variations that reflect changes in demand for port services. Berthing time also fluctuates, influenced by differences in cargo volume, operational readiness in the field, and handling efficiency during cargo operations. Cargo handling productivity demonstrates strong performance, as its values consistently exceed the minimum standard established in the Regulation of the Director General of Sea Transportation No. HK.103/2/18/DJPL-16 concerning Port Operational Service Performance Standards. Meanwhile, BOR values show periods of high utilization and other periods of lower usage, but on average remain within the ideal standard range.

Based on the overall findings, it cannot simply be stated that the operational performance of the Vertical Retaining Wall Wharf is fully "effective" without qualification. Although cargo handling productivity generally meets or exceeds the established performance targets, the average Berth Occupancy Ratio (BOR) of 82.04% indicates that the berth is operating above the recommended utilization threshold of 70–75%. In port operations, a consistently high BOR at this level reflects a condition of intensive berth utilization, which increases the risk of congestion, longer waiting times, and potential service level deterioration, especially during peak months.

Therefore, the operational performance of the Vertical Retaining Wall Wharf can be described as high-performing in terms of productivity but operating under capacity pressure. The wharf demonstrates the ability to handle dynamic vessel demand; however, the elevated BOR suggests that the system has limited buffer capacity to absorb demand surges without affecting service efficiency. In other words, performance is strong, but resilience against peak congestion remains constrained.

Given the average BOR of 82.04%, several practical recommendations are necessary to prevent future operational bottlenecks. First, port management should strengthen berth scheduling and slot allocation planning, particularly during historically high-demand months identified in the analysis. Second, optimizing turnaround time through stricter coordination between stevedoring teams, shipping agents, and equipment operators can reduce berthing duration and indirectly lower BOR. Third, preventive maintenance scheduling should avoid peak seasons to maximize berth availability when demand is highest. Finally, if high utilization persists over multiple cycles, management should consider medium- to long-term capacity strategies, such as operational reconfiguration, additional equipment support, or evaluating the feasibility of berth expansion.

In conclusion, Vertical Retaining Wall Wharf shows solid operational capability, but the sustained high BOR signals that the berth is functioning close to its capacity limit. Without proactive management measures, continued demand growth may translate into measurable congestion and service performance decline in the future.

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