Jurnal Teknik Industri: Jurnal Hasil Penelitian dan Karya Ilmiah dalam Bidang Teknik Industri

Vol. 11, No. 1, 2025

Efficiency Improvement in Raw Material Inventory Management Using EOQ and POQ
(Study Case: PT. Varia Usaha Beton)

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ABSTRACT

This study aims to calculate the need for inventory and ordering of raw materials for concrete production at PT. Varia Usaha Beton optimally so that there is no excess or shortage of inventory to minimize total costs using the EOQ and POQ methods, and comparing the EOQ and POQ methods that will be applied. This study is a descriptive study with a quantitative approach. Data collection is carried out using observation and interview techniques. The results of this study show that by the EOQ method, the quantity of cement raw material orders is 3,109.01 tons with an ordering period of 3 times per year and a total inventory cost of Rp124,110,362.54. Then, in the POQ method, the quantity of cement raw material orders is 708.12 tons with an ordering frequency of 12 times in one year, with an annual inventory cost of Rp368,875,317.77. With the EOQ method, the quantity of raw materials ordered for sand is 9,630.01 tons with an ordering period of 3 times per year and a total inventory cost of Rp 126,473,726.00. Then, in the POQ method, the quantity of raw materials ordered for sand is 2,515.78 tons, with an ordering frequency of 12 times in one year, with an annual inventory cost of Rp 368,875,317.77. With the EOQ method, the quantity of raw materials ordered for stone is 8,383.57 tons with an ordering period of 3 times per year and a total inventory cost of Rp 111,871,065.21. Then, in the POQ method, the quantity of raw materials ordered for stone is 2,429.67 tons, with an ordering frequency of 12 times in one year, with an annual inventory cost of Rp 242,855,765.96. Thus, using the EOQ method produces a lower total cost than the POQ method, by implementing the EOQ method in managing raw material inventory at PT. Varia Usaha Beton in 2023 is projected to save 80.5% of the previous costs on cement raw materials, 80.8% on sand raw materials, and 81% on stone raw materials.

Keywords*: Inventory Control, Inventory, Economic Order Quantity, Periodic Order Quantity*

Introduction

A manufacturing company is a type of company that uses machines, equipment, and labor to convert raw materials into finished goods that have a selling value. In other words, the main activity of this company is to process raw materials into finished products that have a selling value and are widely marketed to consumers. The production process in a manufacturing company is generally carried out based on specific Standard Operating Procedures (SOPs), which serve as work guidelines [1]. Usually, manufacturing companies carry out production on a large scale with the primary goal of making a profit [2]. In the manufacturing industry, efficient management of raw material inventory is one of the key factors in increasing a company's productivity and profitability, especially in the concrete industry sector [3]. PT. Varia Usaha Beton, one of the leading players in this industry, faces challenges in maintaining a smooth production process that is highly dependent on the availability of raw materials on time and in the right quantities. In this context, improving raw material inventory is very important to ensure the company can meet market demand without experiencing an excess or shortage of raw material inventory. In the concrete industry sector, raw material inventory management is critical because errors in managing it can cause various problems, such as excess inventory, which causes high storage costs, or shortages of inventory, which can disrupt the production process and cause products to be delayed to customers [4]. Costs are related to the importance of effective inventory management. In inventory management, some costs that need to be considered are storage costs, ordering costs, and the risk of obsolete goods. Companies can experience losses if not appropriately managed [5][6]–[8]. PT. Varia Usaha Beton, Plant BSP is a company engaged in the manufacturing industry, the construction sector, specifically

infrastructure and property development, which produces Ready-Mix Concrete (BSP) and trades, where the production process is based on customer orders. Timeliness of product completion is critical [3]. In this case, of course, the company must be able to complete its production according to the specified time. PT Varia Usaha Beton BSP was founded in 1991 and is part of the PT. Semen Indonesia Beton Group. PT. Varia Usaha Beton BSP focuses on producing and selling ready-mix concrete, masonry concrete, and machine-made crushed stone/coarse base—the goal of PT. Varia Usaha Beton BSP is to become the leading choice of concrete companies for customers in the national market. The company is highly dependent on the availability of raw materials such as cement, sand, water, stone, and other additives to produce high-quality and standardized products.

Table 1. Cement Raw Material Supply and Needs

Cement Raw Material Requirements (In Tons)				
Month	**Initial Inventory**	**Raw Material Inventory**	**Raw Material Requirements**	**Ending Inventory**
January	29,40	1442,61	1443,05	38,97
February	38,97	366,15	382,65	17,47
March	17,47	381,92	339,79	59,60
April	59,60	270,28	301,62	28,26
May	28,26	288,25	246,90	69,61
June	69,61	421,67	421,89	69,39
July	69,38	619,68	626,27	62,79
August	62,79	627,79	598,30	92,28
September	92,28	586,60	613,76	65,12
October	65,12	840,15	871,88	33,39
November	33,39	1147,59	1142,61	38,37
December	38,37	1504,61	1498,26	44,72

Based on the data above, for example, what PT? Varia Usaha Beton is currently facing the problem of often having excess raw material inventory, which can disrupt the production process and cause the company to lose money. This problem requires an appropriate method to determine raw material inventory so that the company can minimize total costs. Based on these problems, PT. Varia Usaha Beton needs to design and control raw material inventory effectively by considering consumer needs and desires. For this reason, a comparison of methods is required to determine the most appropriate approach for the company. The two methods used are Economic Order Quantity (EOQ) and Period Order Quantity (POQ). The EOQ method aims to calculate the amount of raw material purchases that can minimize inventory costs.[9]–[11]. In contrast, the POQ method focuses on increasing the effectiveness of ordering frequency to make it more structured. POQ is the development of EOQ, which changes the order quantity to a more optimal frequency[12]–[14].

Harris [15] Stated that efficient inventory management is critical to maintaining smooth production and avoiding high costs due to excess or shortage of raw material stock that can disrupt operational processes. In this context, improving raw material inventory is very important to ensure that companies can meet market demand without experiencing an excess or shortage of raw material inventory.

Wang and Xu [16] The concrete industry requires a flexible inventory system to respond to fluctuating market demand and ensure that raw material supplies are always available. Therefore, companies must take an integrated approach to managing raw material inventory.

In their journal, Chandra and Kumar [6] explain that proper management can reduce operational costs and increase the timeliness of product delivery. Using EOQ and POQ methods will greatly help companies achieve efficiency in inventory management.

Kotler and Keller[17] Stated that one way to achieve efficiency in inventory management is to implement a just-in-time (JIT) system to reduce storage costs and increase responsiveness to market demand. This is especially relevant for the concrete sector, which requires a consistent and timely supply of raw materials.

Chopra and Meindl [18] Suggest using information technology to improve the accuracy of large-scale inventory planning and control, which is very relevant for large companies such as PT Varia Usaha Beton.

Lee et al. [19] Also, emphasize the importance of accurate data management through an ERP (Enterprise Resource Planning) system in monitoring and optimizing raw material inventory. This allows companies to better predict raw material needs and avoid waste.

Meanwhile, according to [20] Real-time inventory monitoring is crucial to ensure that companies do not experience supply shortages that can disrupt operations. Thus, effective inventory management using methods such as EOQ and POQ can reduce costs and increase productivity.

Research Methods

This study uses a quantitative descriptive approach to describe the condition of raw material inventory at PT. Varia Usaha Beton and analyze the efficiency of inventory management. The quantitative approach allows the processing of numerical data obtained from the company, including data on inventory, purchases, and the use of raw materials. According to [10], [21]This approach is suitable for analyzing and describing phenomena in the field. This research was conducted at PT. Varia Usaha Beton is located at Jl. Semen Indonesia, Ds. Karang Asem, Kec. Jenu, Kab. Tuban, East Java, in October 2024. The focus of the research is on the process of managing raw material inventory by assessing the inventory policies implemented by the company and evaluating the use of inventory control methods such as Economic Order Quantity (EOQ) and Periodic Order Quantity (POQ), which, according to [22]–[24] There are effective methods for optimizing raw material stock management. The population of this study includes all raw materials used in concrete production, including cement, sand, stone, additives, and fly ash. However, sample selection is focused on raw materials that significantly impact inventory costs, such as cement, sand, and stone. [25], [26] Proper sample selection can help make a more focused and efficient analysis. Data collection techniques include interviews with related parties to obtain information on inventory control, direct observation at the research location, and literature studies to explore literature relevant to the method studied, which, according to Creswell (2014), is a valid approach in quantitative research. Data is processed by collecting information from various sources such as observations, interviews, financial reports, and raw material inventories. Storage and ordering costs are calculated to compare traditional inventory control methods with more efficient approaches. The results of data analysis are used to identify problems in inventory, such as excess or shortage of raw materials, and to find more efficient solutions in managing them. Helander [9] stated that identifying inventory management problems is the first step to improving operational efficiency.

Results and Discussion

Data Collection

The data was obtained through several methods, such as interviews with owners or employees, direct observation on site, and analysis of data summaries that are already available in the company.

Economic Order Quantity (EOQ) Calculation

The service factor value is obtained based on the safety factor above in Figure 4. The tolerance limit that is still acceptable is 2%, and the service ratio is 98%, which PT sets. Varia Usaha Beton, so it has a Z value = 2.05.

1. Cement Raw Material Cost Data

Table 2. Cement Ordering and Storage Costs

No	Cost Components	Cost
1	Ordering Costs	Rp 26.105.456,21/order
2	Storage Costs	Rp 45.842,54/ton

2. Sand Raw Material Cost Data

Table 3. Sand Ordering and Storage Costs

No	Cost Components	Cost
1	Ordering Costs	Rp 19.795.615,18/order
2	Storage Costs	Rp 12.887,29/ton

3. Stone Raw Material Cost Data

Table 4. Stone Ordering and Storage Costs

No	Cost Components	Cost
1	Ordering Costs	Rp 16.083.789,36/order
2	Storage Costs	Rp 13.344,08/ton

4. Calculating EOQ

$$EOQ = \sqrt{\frac{2.S.D}{H}}$$

Description:
EOQ = Optimal Order Quantity
S = Ordering Cost for each order (Rp)
D = Demand Quantity in One Period (ton)
H = Storage Cost (Rp)

a. EOQ of cement raw materials

$$EOQ = \sqrt{\frac{2(26.105.456{,}21 \times 8.486{,}98)}{45.842{,}54}}$$

$= 3.109{,}01$ Tons of cement,

b. EOQ of stone raw materials

$$EOQ = \sqrt{\frac{2(16.083{,}789{,}36 \times 29156.04)}{13{,}344{,}08}}$$

$= 8.383{,}57$ tons of stone

EOQ, and raw material

$$EOQ = \sqrt{\frac{2(19.795.615{,}18 \times 30189.47)}{12{,}887.29}}$$

$= 9.630{,}44$ tons of sand

5. Calculating Order Frequency

$$\mathbf{f} = \frac{\mathrm{D}}{EOQ}$$

To determine the frequency of orders in one year (order interval), the formula used is:

$$\mathbf{T} = \frac{\text{Number of working days in one year}}{Order\ frequency}$$

a. Frequency of ordering cement raw materials

$$\mathbf{f} = \frac{8.486{,}98}{3.109{,}01}$$

$= 2{,}72$ rounded up to 3

$$\mathbf{T} = \frac{312}{2{,}72}$$

$= 114{,}70$ rounded up to 115

b. Frequency of ordering raw sand materials

$$\mathbf{f} = \frac{30189.47}{9630{,}44}$$

$= 3{,}13$ rounded up to 3

$$\mathbf{T} = \frac{312}{3{,}13}$$

$= 99{,}68$ rounded up to 100

c. Frequency of ordering raw stone materials

$$\mathbf{f} = \frac{29156{,}04}{8383{,}57}$$

$= 3{,}47$ rounded up to 3

$$\mathbf{T} = \frac{312}{3{,}47}$$

$= 89{,}91$ rounded up to 90

6. Calculating Safety Stock

To calculate the standard deviation, use the formula below:

$$\sigma = \sqrt{\frac{\Sigma(X-\bar{x})^2}{n}}$$

Information:
σ = Standard deviation
x = Monthly usage
$\bar{x}$ = Average usage in one period

n = The number of months in a period

Regarding the safety factor, the service factor value is obtained, the tolerance limit that is still acceptable is 2%, and the service ratio is 98%, which PT determines. Varia Usaha Beton so that it has a Za value = 2.05= 2.05.

$SS = \sigma \times Za$

a. Cement Safety Stock
   Cement usage in one period = 8486.98
   Average usage in one period = 707.28
   Therefore, the standard deviation value of cement:
   $\sigma = \sqrt{\frac{\Sigma(8486{,}98-707{,}28)^2}{12}}$ = 419,24 ton
   $SS = 419{,}24 \times 2{,}05 = 859{,}442$ ton
b. Safety Stock Sand
   Cement usage in one period = 30189.47
   Average usage in one period = 2515.78
   Therefore, the standard deviation value of cement:
   $\sigma = \sqrt{\frac{\Sigma(30189{,}47-2515{,}78)^2}{12}}$ = 1209,82 ton
   $SS = 1209{,}82 \times 2{,}05 = 2480{,}131$ ton
c. Safety Stock Stone
   Cement usage in one period = 29156.04
   Average usage in one period = 2429.67
   Therefore, the standard deviation value of cement:
   $\sigma = \sqrt{\frac{\Sigma(29156{,}04-2429{,}67)^2}{12}}$ = 1229,72 ton
   $SS = 1229{,}72 \times 2{,}05 = 2520{,}926$ ton

7. Calculating ROP

The reorder point is the amount of inventory that indicates when a reorder must be made so that the ordered goods arrive on time.

d = $\frac{D}{Number\ of\ jobs\ per\ year}$

Information:

D = Number of Requests in One Period

$ROP = (d \times L) + SS$

Information:

ROP = Reorder point

D = demand

LT = lead time

SS = safety stock

a. ROP of cement raw materials
   d = $\frac{8.486{,}98}{312}$
   = 23,20 ton
   Lead time = 4 days
   $ROP = (d \times L) + SS$
   $ROP = (23{,}20 \times 4) + 859{,}442$
   = 952,24 ton
b. ROP sand raw material
   d = $\frac{30189{,}47}{312}$
   = 96,76 ton
   Lead time = 4 days
   $ROP = (d \times L) + SS$
   $ROP = (96{,}76 \times 4) + 2480{,}131$
   = 2867,171 ton
c. ROP stone raw materials

d = $\frac{29156,04}{312}$
= 93,44 ton
Lead time = 4 days
$ROP = (d \times L) + SS$
$ROP = (93,44 \times 4) + 2520,926$
= 2894,686 ton

8. Total Inventory Cost EOQ

After calculating the total inventory cost using EOQ, safety stock, and reorder point, the next step is to calculate the total inventory cost. The total inventory cost can be calculated by adding the ordering and storage costs. The following total inventory cost can be calculated using the formula:

$TIC = \frac{D}{EOQ}S + \frac{EOQ}{2}H$

a. .a. TIC cement raw materials

$TIC = \frac{8.486,98}{3.109,01}\ Rp\ 26.105.456,21 + \frac{3109,01}{2}\ Rp\ 45.842,54$
= Rp 142.525.169,80

From the total inventory cost formula, the total inventory cost for cement is Rp, calculated by adding up the total ordering and storage costs. 142,525,169.80.

b. TIC raw material sand

$TIC = \frac{30.189,47}{9.630,44}Rp\ 19.795.615,18 + \frac{9.630,44}{2}Rp\ 12.887,29$
= Rp 124.110.362,54

From the total inventory cost formula, by adding up the total ordering and storage costs, the total inventory cost for sand is Rp. 124,110,362.54

c. $TIC = \frac{29.156,04}{8.383,57}Rp\ 16.083.789,36 + \frac{8.383,57}{2}Rp\ 13.344,08$
= Rp 111.871.065,21

From the total inventory cost formula, by adding up the total ordering and storage costs, the total inventory cost for stone is Rp. 111,871,065.21.

Calculation of Period Order Quantity (POQ)

The POQ method can be calculated using the formula:

$POQ = \sqrt{\frac{2.S}{D.H}}$

Information:
D = Number of Requests in One Period
S = Ordering fee/one order
H = Storage costs

According to the data that has been obtained, it is then processed using the Periodic Order Quantity using the following formula:

1. Calculating POQ
   a. POQ Cement Raw Materials

$POQ = \sqrt{\frac{2\times26.105.456,21}{8486.98\times45.842,54}}$

= 0,36 rounded up to 1

The calculation results show that the POQ value is 1, which means that orders are made every period or once a month in a year. Thus, the ordering frequency is 12 times in one year. Based on the POQ formula calculation, the EOQ value for cement is found with the number of POQs of 1. After obtaining the F value (order frequency), the next step is to calculate the POQ to determine the order quantity using the following formula:

Q = $\frac{D}{F}$

Q = $\frac{8486.98}{12}$ = 707,24 ton

Based on the results of the POQ calculation and ordering frequency, it is known that to meet cement needs for one year, 8486.98 tons/year are needed, with an ordering frequency of 12 times a year, with the amount of each order being 707.12 tons.

b. POQ and raw material

$$POQ = \sqrt{\frac{2\times19.795.615,18}{30.189,47\times12.887,29}}$$

$= 0{,}31$ rounded up to 1

The calculation results show that the POQ value is 1, which means that orders are made every period or once a month in a year. Thus, the ordering frequency is 12 times in one year. Based on the POQ formula calculation, the EOQ value for sand is found with the POQ amount of 1. After obtaining the F value (ordering frequency), the next step is to calculate the POQ to determine the order quantity using the following formula:

$Q = \frac{D}{F}$

$Q = \frac{30.189,47}{12}$

$= 2515{,}78$ ton

Based on the results of the POQ calculation and ordering frequency, it is known that to meet the need for sand for one year, 30,189.47 tons/year are needed, with an ordering frequency of 12 times a year, with the amount of each order being 2515.78 tons.

c. POQ stone raw material

$$POQ = \sqrt{\frac{2\times16.083.789,36}{29.156,04\times13.344,08}}$$

$= 0{,}28$ rounded up to 1

The calculation results show that the POQ value is 1, which means that orders are made every period or once a month in a year. Thus, the ordering frequency is 12 times in one year. Based on the POQ formula calculation, the EOQ value for stone is found with the number of POQs of 1. After obtaining the F value (ordering frequency), the next step is to calculate the POQ to determine the order quantity using the following formula:

$Q = \frac{D}{F}$

$Q = \frac{29.156,04}{12}$

$= 2429{,}67$ ton

Based on the results of the POQ calculation and ordering frequency, it is known that to meet the need for stone for one year, 29,156.04 tons/year are needed, with an ordering frequency of 12 times a year, with the amount of each order being 2429.67 tons.

2. Total Inventory Cost POQ

When calculating the safety stock and ROP values, the EOQ and POQ methods are the same. After calculating using POQ, Safety stock, and Reorder point, the next step is to calculate the total inventory cost. The total inventory cost can be calculated by adding the ordering and storage costs. The following total inventory cost can be calculated using the formula:

$TC = (POQ\ x\ S) + (\left(\frac{Q}{2} + Safety\ Stock\right) x\ H)$

a. Cement Total Cost

$TC = (12\ x\ 26.105.456,21) + (\left(\frac{707,24}{2} + 859,442\right) x\ 45.842,54)$

$=$ Rp 368.895.488,49

From the total inventory cost formula, the total inventory cost for cement is Rp, calculated by adding up the total ordering and storage costs. 368,875,317.77.

b. Sand Total Cost

$TC = (12x19.795.615,18) + (\left(\frac{2515,78}{2} + 2480,131\right) x\ 12.887,29)$

= Rp 285.720.342,81

From the total inventory cost formula, by adding up the total ordering and storage costs, the total inventory cost for sand is Rp. 285,720,342.81.

c. Total Cost of Stone

$TC = (12\ x\ 16.083.789,36) + (\left(\frac{2429,67}{2} + 2520,926\right) x\ 13.344,08$

$=$ Rp 242.855.765,96

From the total inventory cost formula, by adding up the total ordering and storage costs, the total inventory cost for stone is Rp. 242,855,765.96.

Inventory Analysis

Economic Order Quantity (EOQ) determines the optimal purchase quantity in one order by considering the ordering and storage costs. When the number of items ordered increases, the storage cost will increase, while the ordering cost tends to decrease. Therefore, EOQ functions to balance both types of expenses. With the EOQ method, the optimal order quantity, safety stock, reorder point (ROP), and raw material ordering cycle, such as cement, sand, and stone, can be calculated to minimize the total inventory cost. Inventory planning using the EOQ method is also the basis for calculating the total inventory cost.

Table 5. Raw Material Inventory Planning In 2023 Using the EOQ Method

Raw Materials	Annual requirement (tons)	Optimum Order Quantity (tons)	Safety Stock (ton)	ROP (ton)	Order Frequency (times)	Order Interval (days)
Cement	8.486,98	3.109,01	859,442	952,24	3	115
Sand	30.189,47	9.630,44	2.480,131	2867,171	3	100
Stone	29.156,04	8.383,57	2520,926	2894,686	3	90

Table 6. Raw Material Inventory Planning in 2023 Using The POQ Method

Raw Materials	Annual requirement (tons)	Optimum Order Quantity (tons)	Safety Stock (ton)	ROP (ton)	Order Frequency (times)
Cement	8.486,98	707,24	859,442	952,24	12
Sand	30.189,47	2515,78	2.480,131	2867,171	12
Stone	29.156,04	2429,67	2520,926	2894,686	12

Comparative Analysis of Total Cost

This test determines the total inventory cost based on alternative order quantities and ordering cycles. The order quantity is optimal if it minimizes the total inventory cost. To analyze or prove that the EOQ and POQ methods can reduce total inventory costs, calculations using both methods are compared with those currently applied by the company (without using EOQ and POQ). Calculating total costs, both with and without methods, is done by adding up the ordering and storage costs. The following is a table of estimated inventory costs for 2023 using both approaches.

Table 7. Comparison of Company Policy Efficiency, EOQ, and POQ for Cement Raw Materials

No	Description	Company	EOQ	POQ	Efficiency
1	Average inventory	708,10	3.109,01	708,12	
2	Order frequency	13	3	12	
3	Total Inventory Cost (RP)	Rp728.431.551,69	Rp142.525.169,80	Rp368.875.317,77	EOQ:80,5% POQ:49,4%
4	Safety Stock		859,442	859,442	
5	ROP		952,24	952,24	

Table 8. Comparison of Company Policy Efficiency, EOQ, and POQ of Sand Raw Materials

No	Description	Company	EOQ	POQ	Efficiency
1	Average inventory	2246,71	9.630,44	2515,78	
2	Order frequency	13	3	12	
3	Total Inventory Cost (RP)	Rp646.403.618,36	Rp124.110.362,54	Rp285.720.342,81	EOQ:80,8% POQ:45,8%

4	Safety Stock	2480,131	2480,131	
5	ROP	2867,171	2867,171	

Table 9. Comparison of Company Policy Efficiency, EOQ, and POQ of Stone Raw Materials

No	Description	Company	EOQ	POQ	Efficiency
1	Average inventory	2297,99	8.383,57	2429,67	
2	Order frequency	13	6	12	
3	Total Inventory Cost (RP)	Rp589.149.882,68	Rp111.871.065,21	Rp242.855.765,96	EOQ:81% POQ:48,8%
4	Safety Stock		2520,926	2520,926	
5	ROP		2894,90	2894,90	

The calculation results show that the EOQ method produces a lower total cost than the POQ method, by implementing the EOQ method in managing raw material inventory at PT. Varia Usaha Beton in 2023 is projected to be able to save costs. Therefore, it is recommended that raw materials be procured at PT. Varia Usaha Beton uses the EOQ method.

Conclusion

Raw material inventory management at PT. Varia Usaha Beton uses the Economic Order Quantity (EOQ) and Periodic Order Quantity (POQ) methods to show significant differences in cost efficiency and stock management. Using the EOQ method, raw cement, sand, and stone materials are purchased optimally, each with a lower ordering frequency but a lower total inventory cost. For example, the purchase of cement raw materials using the EOQ method of 3,109.01 tons only costs Rp124,110,362.54 per year, while the POQ method requires more frequent purchases and results in much higher costs, namely Rp368,875,317.77 per year. The main advantage of using EOQ is its efficiency in reducing total inventory costs and optimizing ordering frequency using this method, PT. Varia Usaha Beton significantly reduced annual inventory costs for the three types of raw materials studied. For example, applying the EOQ method to cement raw materials resulted in cost savings of Rp604,321,189.15, or 80.5% lower than the previous method.

The EOQ method provides more detailed recommendations regarding ordering and stock management, such as optimal ordering intervals, sufficient safety stock, and well-measured reorder points (ROP). Thus, the company can avoid shortages or excess stock that could disrupt smooth production. As a result, inventory costs can be reduced, and inventory remains sufficient to support smooth output without waste. Overall, the application of the EOQ method at PT. Varia Usaha Beton positively impacts operational efficiency and more appropriate and economical raw material inventory management.

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