Sustainability Green Raw Material Inventory with Continuous Replenishment Method: A Case Study Housing Construction Company

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Abstract. The company is engaged in housing construction. Every year their production increase using green materials, from 2018 to 2021. This growth emerges problems such as overstock and dead stock. So the company has to determine the best Inventory Control Method to help the company get so much lost in stock and dead stock. In another way, the company can calculate the total cost for all the inventory activities. In the first calculation, we find the best solution forecast method for the next year in moving averages. The best forecast fit in best criteria, such as Mean Absolute Deviation, Mean Absolute Percentage Error, CFE, and Mean Square Error. Calculating the Inventory Control Method employing continuous replenishment, it is interpreted that the customer is still waiting for the product that has not been fulfilled. This Continuous Replenishment Method can calculate Safety Stock, Reorder Point, and Stock Out to minimize the total cost.

1 Introduction

The demand for housing continues to increase every year, and this can cause problems for housing construction companies in controlling the inventory of raw materials. The raw material control system in housing construction companies often experiences problems due to fluctuating demand, significantly directly impacting the process of procuring goods and materials. In procuring raw materials, PT. X does not use an optimal control system that has a detrimental impact on the company, such as increased storage costs due to the accumulation of raw materials in the warehouse. Material inventory cannot meet demand, which causes enormous losses. For this reason, the appropriate inventory control is a continuous inventory control model where the amount of raw material inventory is monitored at all times. Suppose the amount of raw material inventory reaches the ordering point. In that case, an order for raw materials is made to the supplier so that the company can determine the total cost of raw material inventory for each period. Inventories are materials or products, or assets from an association that is put away that will be utilized to meet specific targets. Each component in an organization must have stock in different structures and capacities. In light of the physical structure, the stock can be as crude materials, work in the procedure, completed merchandise, saved parts, and supplies [1].

Inventory is idle resources that await further processing. It has meant in the form of production, marketing, or consumption activities [2]. Raw material inventory is an inseparable part of a production flow. In general, several components are always closely related in the inventory system, including: Demand is the number of units of goods taken from inventory. Types of requests can be categorized based on the amount of demand, namely the size of the demand and the dimensions of quality or quantity. Goods removed from inventory is a pattern of demand for these goods, whether at the end of the period, the beginning of the period, uniform, or even with a pattern (for example, seasonal).

The elements of an inventory system considered, e.g., size, cost structures, and service level definition, all influence the best method of transhipping [3]. The inventory manager replenishes the warehouse from an outside supplier [4].

Replenishment, this component can also be distinguished based on: the size of the order, which refers to the number of goods to be included in the inventory, the ordering pattern, which refers to how a certain number of units are added to the inventory, and lead time is the span or grace period between the time of ordering an item and the addition of a certain amount. The unit in inventory can be either constant or variable.

Supply chain performance is the primary building block in inventory management practices as the customer needs through product or service availability, at the right time, place, at the right price, and in the right quantities [5]. The constraint is a limiting component of the existing inventory system, as warehouse storage space constraints can limit the amount of inventory that must be held, and capital constraints limit inventory

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investment costs. Facility, equipment, or personnel constraints limit the company's supply capability and level of operations.

The most common inventory components used to calculate inventory costs are as follows.

1. Purchasing cost is the cost incurred to buy goods. This cost is calculated from the number of units of goods and the price.
2. Procurement costs are divided into two, namely:
   - Ordering costs are expenses incurred to bring in goods from outside parties (suppliers), for example, the costs of typing orders, the costs of sending orders, and the costs of receiving.
   - Setup costs are expenses in preparing for the production of an item, for example, the cost of setting up machines and equipment maintenance costs.
3. Holding costs are all fees related to holding inventory, including the capital, taxes, insurance, material handling, facility costs (warehousing), depreciation, theft, and damage.
4. Deadstock costs are incurred by the company when consumer orders are not fulfilled from the existing inventory when the order is received. Two types of conditions include this cost, namely: lost sales costs, which can occur if consumers are faced with a situation where orders cannot be fulfilled, so they cancel the order and look for other similar companies to place the same order and back order costs can occur if consumers willing to wait until the order can be filled, so the sale continues but is delayed for several days.

The purpose of this research is to:

- Determining the most significant risks in inventory control by weighting each identified risk and seeking solutions for the risks that arise.
- Determine the exact amount of stock at the end of the project
- Determine the supply by Order (SBO) material order for phase 1 and 2 projects using the Continuous Replenishment Method.

2 Research methodology

2.1 Green material

Some of the green materials used in the PT X Housing Project development project, the materials used in this research six kinds of materials, namely:

a. Sand
b. Cement
c. 9mm. Plywood
d. Split stone,
e. Ceramic Granite ex China
f. Split

These projects were obtained from several places, from building material traders and other material suppliers.

2.2 Continuous replenishment

The continuous replenishment supply chain's idea is to continue filling inventory by working closely with suppliers and buyers. However, if the filling process involves multiple shipments, the costs may be too high, causing the supply chain to collapse. Therefore, very tight integration is needed between the order fulfilment and production processes. Real-time demand changes are necessary for the production process to maintain the desired filling schedule [6]. Supply Chain Logistics Management mentions that collaborative inventory planning is designed to streamline the flow of goods in distribution channels [7]. There are several specific techniques to meet needs. The goal is to reduce dependence on when and where inventory needs to be positioned to meet consumer or end-user demand rather than allowing suppliers to respond to requests just in time.

Quick response is a collaborative effort between retailers and suppliers to increase inventory speed when implementing a pattern of preparing goods supply that suits consumers. Quick response is carried out by monitoring retail sales for a particular product and sharing information throughout the supply chain to ensure that the right products are available and know where and when they are needed. Continuous Replenishment (CR) and vendor manage inventory (VMI) are modifications of Quick Response that aim to eliminate the need for fulfilment. The distinguishing factor between CR and VMI is who is responsible for setting target inventory levels and making restocking decisions.

The CR buyer makes the decisions, while at VMI, the supplier is more responsible and manages the inventory for the buyer.

a. Risk Management

   The earlier risk contains several responses to respond to this condition, among others, avoiding, reducing, transferring, holding, and sharing risk.

b. Inventory Control or Inventory Management

   After the data is collected, processing begins with the Continuous Replenishment Method, which strengthens the buyer or housing operations in meeting inventory needs. First, a calculation will be made using the data in stage 1, namely Q* or the average number of needs/day with the formula [8]:

$$Q^* = \frac{Demand}{Day}$$

From this daily need, data on ordering costs and storage costs are collected to determine the total cost of inventory which is called the initial Total Cost (TC) if not using the Economically Order Quantity (EOQ) and Reorder Point (ROP) methods. The formula for calculating the total cost of inventory is as follows:

TIC (total inventory cost) = Ordering cost + Carrying cost TIC (total inventory cost)
= Set up cost + Holding Cost As for:

D = number of goods needed for one period (e.g., one year)

S = ordering cost every time the order
H = holding cost per unit inventory value per unit time
t = time between one order to the next order

The calculation of the total cost of the initial inventory is used as a reference for comparison with the calculations using EOQ and ROP. With the same data, the calculation begins using the EOQ and ROP formulas; from here, it will be known how much Q is optimal from the total needs and the most efficient reorder point before the goods are used up.

To know the exact calculation, the standard formulation for EOQ [8] is:

$$EOQ = \sqrt{S \frac{2DS}{H}}$$

As for:
EOQ = Economic Order Quantity D = Annual sales volume, units
S = Ordering cost every time the order
H = Holding cost per order

After everything is calculated, the total cost of inventory is recalculated with the same formula as the Total Cost of Inventory.

3 Result and analysis

Inventory control risk list for this research so that the total weighting of each risk can be known:

Table 1. Risk weighting comparison.

NO	risk description	U	S	G	value
1	overstock	5	4	5	14
2	limited storage space	3	4	4	11
3	delivery delay at the supplier	3	4	4	11
4	lack of Stock	5	5	4	14
5	double procurement because there is no record of the end of the project stock data	3	2	4	9

The weighting results for each of the most significant risks are overstock and understock. Overstock impacts storage costs at the end of the project and causes dead stock. While the stock is lacking, if not managed properly, it will impact the project's progress at a predetermined time. The project's performance will be assessed as poor if it does not match the stipulated time. In the total weighting above, the risk of overstock and lack of stock has the same value. In the matrix below, it is in the High- Risk position.

If using the Continuous Replenishment (CR) method [9], it can be shown that the stock of goods and materials at the end of the phase 1 project is as follows:

Table 2. The remaining stock at the end of the project after using the CR method.

No	item/material name	remaining stock
1	sand	12.33
2	split Stone	5.76
3	split	15.62
4	cement	5.76
5	12. iron	no leftovers
6	10. iron	no leftovers
7	plywood	9.87
8	granite	14.80
9	colour cement	no leftovers
10	polish	no leftovers

With the stock information data above, the housing operation can immediately anticipate it by preparing a particular room for SBO leftovers from the phase 1 project [10]. This information is also helpful for the procurement division of the housing owner because they will not make double purchases if they need the goods or materials above.

In addition to findings regarding the condition of the final stock of the project, other findings were also obtained, including without using the Continuous Replenishment (CR) method and Continuous Replenishment (CR). The following tables compare the two for the delivery duration and total inventory costs in phase 1 and phase 2 projects.

Table 3. Comparison of the calculation of the duration of the delivery of stage 1.

No	item/material Name	no CR	with CR	deviation
1	sand	84	84	0
2	split Stone	120	120	0
3	split	15	15	0
4	cement	17	15	-2
5	12. iron	58	55	-3
6	10. iron	58	56	-2
7	plywood	15	15	0
8	granite	75	85	+10
9	colour cement	65	65	0
10	polish	80	80	0

After completing stage 1, from the calculation results, materials that significantly influence total inventory costs are considered the reference material for calculating SBO materials in stage 2.

Five materials that deserve to be taken into account as a discussion in stage 2, namely:

1. Sand
2. Split stone
3. Split
4. Cement
5. Polish

Table 4. Comparison of the calculation of the duration of the delivery of stage 2.

No	item/material Name	Delivery Time (days)		
		no CR	with CR	deviation
1	sand	65	62	-3
2	split stone	45	45	0
3	split	45	39	-6
4	cement	45	43	-2
5	polish	80	77	-3

In project phase 2, the decrease is indicated by sand, split, cement, and polish, while for crushed stone, there is no change in the duration of delivery.

Table 5. The difference in TC value before and after using CR Stage 2.

No	item/material Name	TC value		deviation	
		before	after	value (Rp)	(%)
1	sand	6,696,102.56	14,507,509.78	2,188,592.78	13.11
2	split Stone	10,574,305.19	8,176,159.69	2,398,145.50	22.68
3	split	12,696,734.81	11,840,639.98	856,094.83	6.74
4	cement	12,359,075.56	11,337,162.40	1,021,913.16	8.27
5	polish	17,986,506.67	12,703,250.36	5,283,256.31	29.37

In calculating inventory costs, all SBO phase 2 materials experienced a significant decrease, so in phase 2, the Continuous Replenishment method could be implemented.

4 Conclusion

Risk Management is one part of Project Inventory Management with potential risks in the analysis. If the risks that arise are not controlled, it will result in the continuity and success of the project. From the calculation of the total cost of inventory without using Continuous Replenishment (CR) and the Continuous Replenishment (CR) method, a comparison is made by showing the weaknesses and strengths of each. So it can be determined whether the Continuous Replenishment (CR) is suitable or not for each of these SBO goods and materials. Calculations used using the EOQ model; some of the reasons for using this model, among others, are that this model is relatively easy to use but is still based on several assumptions:

a. Only one product is taken into account
b. Demand is known, fixed, and independent
c. Acceptance of orders is known and constant
d. The goods ordered are assumed to be available immediately, or the production rate of the goods ordered is abundant. Receipt of inventory is instantaneous and complete. In other words, inventory from within one shipment can be used immediately.
e. The only variable costs that exist are setting costs or setup costs and holding costs or inventory storage.
f. Shortage can be wholly avoided if ordering is done at the right time
g. Backorders due to running out of inventory
h. There is no quantity discount for a large number of purchases

The above conditions can be said to be similar to this research, namely, in the construction project stage 1 and stage 2, the work can be determined in terms of the time of work and the number of goods sent. Things that can be taken from this research are the problems that occur in PT. X can be solved by using the Continuous Replenishment method because overstock and dead stock can be minimized with this method.

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