Effective Inventory Management System in Construction

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Abstract: *Inventories are raw materials, work-in-progress goods and completely finished goods that are considered to be the portion of company's assets that are stored or reserved for smooth, efficient and effective functioning of project. Just as inventory is the stock of any item or resource used in an organization,* ***an inventory management system*** *is the set of policies and controls that monitor levels of inventory and determine what levels should be maintained, when stock should be replenished, and how large orders should be. The project is primarily concerned with the application of* ***quantitative techniques*** *in the management of inventory in Construction and also in the classification of the materials according to their usage. Based on the major findings from the analysis of data, conclusions are drawn and recommendations are made on how to ensure effective management of stocks in construction sites for smooth flow of project.*

Keywords: *inventory, stocks, inventory management, inventory control, materials classification.*

1. Introduction:

Inventory consists of the goods and materials that a retail business holds for sale or a manufacturer keeps in raw materials for production. Inventory control is a means for maintaining the right level of supply and reducing loss to goods or materials before they become a finished product or are sold to the consumer. Inventory control is one of the greatest factors in a company's success or failure. This part of the supply chain has a great impact on the company's ability to manufacture goods for sale or to deliver customer satisfaction on orders of finished products. It includes:

- Policies, procedure and techniques employed in maintaining the optimum number or amount of each inventory item.
- Systems and processes that identify inventory requirements, set targets, provide replenishment techniques and report actual and projected inventory status.
- Handles all functions related to the tracking and management of material. Also may include ABC analysis, lot tracking, cycle counting support etc.

Successful inventory management involves balancing the costs of inventory with the benefits of inventory. Effective Inventory management system involves active part of both Inventory control and Inventory management:

Effective Inventory Management System = Inventory Management + Inventory Control

2. Objectives of the project:

In India, construction materials and equipment may constitute more than 70% of the total cost for a typical construction project. Therefore the proper management of the single largest component can improve the productivity and cost efficiency of a project and help ensure its timely completion**.** The main objective of the project is to minimize the total inventory costs and to provide optimum material quantities for production at right time, thereby increasing the profitability of the organization. Other objectives include:

- Ensuring Availability of Materials
- Avoidance of Abnormal Wastage
- Avoidance of Out of Stock Danger
- Economy in purchasing
- Reasonable Price
- Optimum Investing and Efficient Use of capital

3. Review of Literature:

Inventory management system involves procurement, storage, identification, retrieval, transport and construction methods. Each is indelibly linked to safety, productivity and schedule performance [8].

Material management leads to effective cost control and materials control, reduces failure of a project and also reduces the incidence of project abandonment. Management should therefore incorporate inventory management in their corporate policy to improve the quality and time execution of their projects [1].There should be a centralized material management team co-ordination between the site and the organization. Proper control, tracking and

monitoring of the system is required. Firms employing proper material management system are seen to have increased their overall efficiency by 35% [2].The average values as well as variability of inventory level decreases significantly so as to minimize economic costs related to inventory management under uncertain project condition [3].

There is a need for more sophisticated technology to be implemented in construction project in order to facilitate materials tracking process and at the same time, reduce dependency on paper-based reports in inventory management [4].Only 60% of companies use skilled and trained professionals for stock management. Among the companies following inventory control techniques ABC Analysis is the most used control technique. The 50% Companies use the stock overflow in other activities [5].

An Economic Order Quantity (EOQ) and a Reorder Point was recommended to help them reduce their product stock outs. The shortage of raw material for production always makes the process discontinuous and reduces the productivity [6].Many firms have not yet established how much to invest in inventories, the right inventory levels to hold so as satisfy customers. Organizations have therefore turned to using modern technology so as to overcome such challenges [7].

A classes are those that constitute **45%** of total components. **B** classes are those that constitute **35%** of total components and **C** classes are those that constitute **30%** of total components. F items are those which moves fastly and constitutes 43% of total components. S items are those which moves slowly constitute 57% of total components and N items are those which don't move (Non-moving items) [9].

If defective rate increases, the order quantity increases while shortages decrease under the same unit purchasing cost. When all items are perfect (that is, no screening process is needed) and the supplier does not provide quantity discounts [10].

4. Basic terms in Inventory:

Inventories are stock of the product a company is manufacturing for sale and components that make up the product. The various forms in which inventory exist in a manufacturing company are raw materials, work in progress and finished goods. Some of the terms involved in inventory are:

4.1. Item costs:

Item cost is the cost of the product in buying and/or producing individual inventory items and is usually expressed as a cost per unit multiplied by the quantity procured. This cost consists of purchase costs from suppliers, freight cost, custom duties for item, and insurance cost from supplier to buyer's warehouse

4.2. Ordering costs:

Ordering costs have to do with placing orders, receiving and storage. Transportation and invoice processing are also included.

4.3. Carrying costs:

This is the cost of holding or keeping inventories for a period, and hence called holding cost. These can be financial holding costs and non-financial costs. Other carrying costs in this category are warehouse operation costs, insurance & security, salary & statutory payments to stores and verification personnel, taxes and obsolescence (non-salable or lose it freshness) or loss, stationery & documentation charges for stock management, computer usage in stores, price erosion and revaluation, and risk costs.

4.4. Economic Order Quantity (EOQ):

How much inventory should be bought in a lot? Should the requirements of material during a given period (say 6 months or 1 year) be acquired in one lot or should it be acquired in installments or in several small lots? EOQ is that level of inventory at which total cost of inventory comprising ordering cost & carrying costs is the minimum. To be able to calculate a basic EOQ, certain assumptions are necessary: [11]

- That there is a known, constant, stock holding cost
- That there is a known, constant ordering cost
- That the rates of demand are known
- That there is a known constant price per unit
- That replenishment is made instantaneously, that is the whole batch is delivered at once
- No stock-outs are allowed

Formulae for calculating Economic Order Quantity:

$$EOQ = \sqrt{\frac{2AO}{C}}$$

Where,

A= Annual Quantity

O= Ordering Cost

C= Carrying Cost

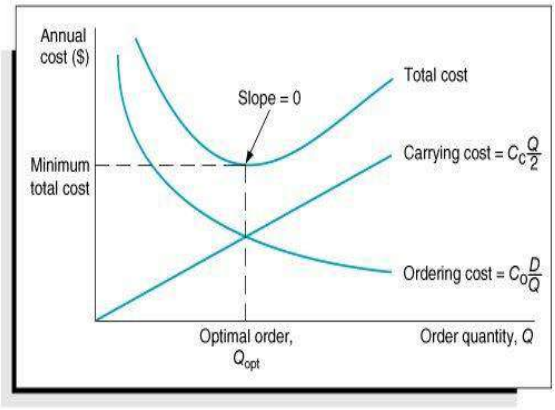

Figure 1. Costs Vs EOQ graph

4.5. Lead – Time:

It is the time between placing an order and its realization in stock. It can be deterministic or probabilistic. If both demand and lead–time are deterministic, one needs to order in advance by a time equal to lead-time.

4.6. Reorder Point:

This is the point at which to order inventory and expressed in equation as:

Lead Time in days x daily usage.

4.7. Safety Stock:

It implies extra inventories that can be drawn down when actual lead-time and/or usage rates are greater than expected

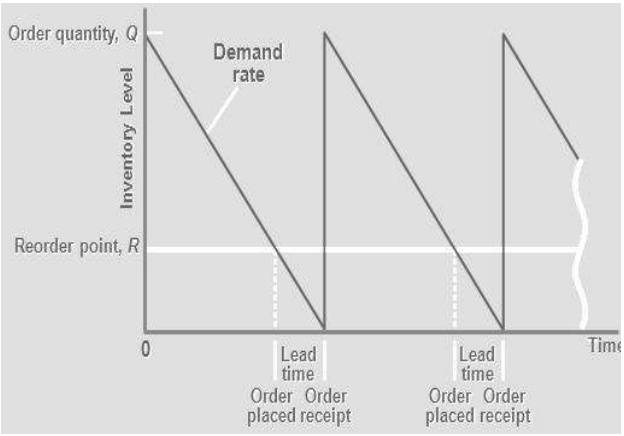

Figure 2. Inventory distribution system

5. Research Methodology:

The data pertaining to December 2015 to December 2016 are considered for the analysis. Carrying costs will be 26% of unit purchase costs, therefore the Economic Order Quantity for each material is found out:

Table 1: *Economic Order Quantity*

Sl. no	Materials	Price	Annual Demand	EOQ
01	Cement	300/bag	86,318	1,280
02	Steel	45,000/MT	990.155	13
03	Blocks	45/unit	45,625	3,245
04	Sand	1112/m^3	6,692	260
05	Gravel	667/m^3	11,123	408.4
06	**Store Durables**			
6.A	Mortar pan(big)	93/unit	58	15
6.B	Spade with handle	154/unit	49	15
6.C	Mortar pan(small)	51/unit	88	36
6.D	Shovel with handle	279/unit	5	3
6.E	Measure tape (30m)	319/unit	2	2
6.F	Measure tape (15m)	278/unit	2	2
6.G	Plum bob	51/unit	7	7
6.H	Wheel barrow	5496/unit	5	3
6.I	Gugoo bolt	75/unit	5534	168
6.J	Ceiling fan	633/unit	12	5
6.K	Measure tape(5m)	78/unit	19	13
6.L	Measure tape(3m)	52/unit	3	3
6.M	Hammer 2lbs	63/unit	12	12
6.N	Hammer 3lbs	94/unit	10	7
6.O	Hammer 5lbs	143/unit	11	7
6.P	Silpaulin sheets	654/unit	25	5
07.	**General Stores**			
7.A	1" Curing Hose Pipe	38/m	503	142
7.B	3/4" Curing Hose Pipe	28/m	425	152
7.C	Hacksaw Blade	5/unit	210	179
7.D	Cotton Waste	33/kg	64	27
7.E	Binding Wire	56/kg	6261	293

7.F	Thermofoam Sheet	23/unit	1527	225
7.G	Thermocoal Sheet 25mm	24/unit	65	45
7.H	Shuttering Oil	54/lit	1703	155
7.I	Heassian Cloth	13/yard	6973	642
7.J	Sponge	11/unit	423	171
7.K	Tube Level	79/roll	15	12
7.L	PVC Cover Block 40mm	2/unit	18329	2655
7.M	PVC Cover Block 50mm	2/unit	23300	2993
7.N	PVC Cover Block 25mm	1/unit	37100	5342
7.O	Putty Blade 8"	8/unit	7	7
7.P	Putty Blade 6"	6/unit	6	6
08.	**Safety products**			
8.A	Safety helmets	119/unit	314	45
8.B	Shoes	580/unit	350	21
8.C	Rubber hand gloves	36/unit	4250	301
8.D	Safety net	400/unit	331	25

5.1. EOQ policy Vs Present policy:

For cement,

Total cost=[(Annual demand/EOQ) x Ordering cost]
(By EOQ) +
[(EOQ/2) x Carrying cost]
+
[Price x Annual demand]

By EOQ policy, total cost= Rs. 2,59,95,223

As per present ordering system,

Order size=Annual demand/12
=7193

By Present policy, total cost= Rs. 2,61,84,814

The total cost as per the EOQ policy is lesser when compared to the present ordering system and the corresponding cost advantage is Rs. 1,89,591 per year (i.e. Rs. 2,61,84,814 – Rs. 2,59,95,223). Hence adopting inventory EOQ policy in any organization results in profitability.

5.2. ABC Analysis:

The ABC system is a widely used classification technique to identify various items of inventory for purposes of inventory control. ABC analysis is an inventory categorization method which consists in dividing items into three categories, A, B and C: A being the most valuable items, C being the least valuable ones and B deserve less attention than A but more than C. This method aims to draw attention on the critical few (A-items) and not on the many (C-items). The ABC approach states that, when reviewing inventory, a company should rate items from A to C, basing its ratings on the following rules: A-items are goods which annual consumption value is the highest. The top 70-80% of the annual consumption value of the company typically accounts for only 10-20% of total inventory items. B-items are the interclass items, with a medium consumption value. 15-25% of annual consumption value typically accounts for 30% of total inventory items. C-items are, on the contrary, items with the lowest consumption value, 5% of the annual consumption value typically accounts for 50% of total inventory items. It has the following steps of calculation [12]:

1. Calculate annual usage in units for each item for the past years.
2. Calculate the annual usage in currency for each item
3. Multiply the annual usage in units with its value to get annual usage for item (i.e. multiply values obtained in step 1& 2).
4. Sort the annual usage value from the highest to the lowest for ranking
5. Arrange the items in the inventory by cumulative annual usage currency value and determine its percentage

Table 2: *ABC Analysis of Inventories*

Material	**Annual consumption**	**Cumulative Annual consumption**	**%**	**Class**
Steel	4,45,56,963	4,45,56,963	49	A
Cement	2,58,95,459	7,04,52,422	77	B
Sand	74,41,240	7,78,93,662	85	B
Gravel	74,19,082	8,53,12,744	93	C
General Stores	30,86,032	8,83,98,776	97	C
Blocks	20,53,115	9,04,51,891	99	C
Store Durables	3,10,350	9,07,62,241	99	C
Safety products	3,01,129	9,10,63,370	100	C

From the table 2, Steel falls under class ‘A’ which is the most critical item of inventory, cement and sand falls under class ‘B’ which has got the average value of inventory items and blocks, gravel and other materials comes under class ‘C’ which are the least valuable items.

5.3. Safety stocks:

The minimum level of inventory may be expressed in terms of several days' sales. The level can be calculated by multiplying the usage rate and time in the number of days that the firm wants to hold as a protection against shortages. In the given table, safety stocks for the various components calculated are shown. Actual demand is given for each component for a period of 1 year and the lead-time is calculated at a maximum of 90 days & normal of 60 days and these were converted into per annum. So, from calculation of safety stock, we can able to determine how much the company can hold the inventory in reserve stock per annum.

Table 3: *Safety Stocks of Inventories*

Materials	**Max Lead Time**	**Normal Lead Time**	**Annual demand**	**Safety stock**
Steel	0.24	0.16	990.1MT	79.2MT
Cement	0.24	0.16	86,318bags	6,905bags
Blocks	0.24	0.16	45,625Nos.	3,650Nos.
Sand	0.24	0.16	6,692m^3	535.36m^3
Gravel	0.24	0.16	11,123m^3	889.84m^3

6. Purchase Model of Inventory for Multi-item Joint Replenishment without Shortages:

In practice, the order processing department of a company may process the purchases of multi-item jointly to replenish them. Under such situation, the ordering cost is to be redefined. It has a fixed component which is the cost to the organization for processing the common activities involved in purchasing all the items in the group of items that is being purchased jointly and a variable cost which is specific to each item in the group. This variable cost/marginal cost of processing some specific purchase activities of an item which are not part of the common activities for the entire group of items depends on that item. Hence, the variable cost of an item is called as *marginal cost* or *item dependent cost* of that item. In this project, if the company plans to order for three items jointly, the details are given below:

Table 4: *Safety Stocks of Inventories*

Material	**Annual demand (units),D_m**	**Price /unit, p_m**	**Annual demand (Rs.),dr_m**	**Marg-inal cost(Rs.)**
Steel	990.155	45000	44556975	3000
Cement	86318	300	25895400	4000
Blocks	45625	45	2053125	2500
Total			72505500	9500

Fixed ordering costs (C_o) = Rs.20000

Sum of marginal costs of ordering the items ($\sum C_{om}$) = Rs.9500

Annual demand in rupees of all items in the group (Dr) = Rs.7,25,05,500

Inventory carrying charge percentage in decimal (I) = 0.26

Therefore, the EOQ in rupees of all the items put together in the group (Qr) is computed as shown:

By [13],

$$Qr = \sqrt{\frac{2(Co + \sum_{i=1}^{3} \text{Com})\text{Dr}}{\text{I}}}$$

$$= \sqrt{\frac{2 \times (20000 + 9500) \times 72505500}{0.26}}$$

= Rs. 40,56,250.87

From the value of Qr, the value of qr_m and Q_m for each of the materials are computed as shown below,

$$qr_1 = \frac{dr_1}{Dr} \times Qr$$

= (44556975/72505500) x 4056250.87
= Rs.2492697.36

$$qr_2 = \frac{dr_2}{Dr} \times Qr$$

= (25895400/72505500) x 4056250.87
=Rs. 1448693.39

$$qr_3 = \frac{dr_3}{Dr} \times Qr$$

= (2053125/72505500) x 4056250.87
=Rs. 114860.11

Similarly, the EOQ in units of each material *m* is computed using the formula,

$Q_m = {qr_m}/{p_m}$, for m = 1,2,3,…..,m.

$Q_1 = {qr_1}/{p_1}$=2492697.36/45000=55.39 MT

$Q_2 = {qr_2}/{p_2}$=1448693.39/300=4829 bags

$Q_3 = {qr_3}/{p_3}$=114860.11/45=2552.44 units

$N = {Dr}/{Qr}$=72505500/4056250.87=17.87

$T = {1}/{N}$=1/17.87=0.055 year=20.42 days

7. Findings and Conclusion:

In the present scenario, the need for effective inventory management has become an area of major

concern in construction costs. Some of the observations in the above followed inventory management system are:

- EOQ estimation for inventory stocks and the comparison of present ordering system with respect to prescribed EOQ ordering system,
- The results by implementing EOQ policy saves the total costs by Rs.189591(For Cement),
- Classification of available inventories by ABC Analysis shows that Steel constitutes 70% annual consumption value and 10% of total inventory,
- Cement, Sand constitute 15-25% annual consumption value and 30% of total inventory,
- Gravel, Blocks, General stores and Store durables constitute only 5% of annual consumption value and 50% of total inventory,
- Safety stocks had been computed for an excess lead time of 30 days to be maintained throughout the project,
- An Inventory Modeling has been done for multi-item joint replenishment by which EOQ for individual material in a group orders had been determined and no. of orders per year also had been found.

Thus, A Construction Company is said to have an Effective Inventory Management system, if it follows and implements the entire above mentioned inventory control steps like EOQ estimation, Safety stocks computation, classification and modeling.

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