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# A Review on Optimization of Material Cost through Inventory Control Techniques

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**Abstract -** *Materials management is a major and essential part of the construction industry since construction materials generally comprise a major portion of the total cost involved in construction projects. Materials management aims at optimization of inventory cost to make sure continuity in the availability of materials. An important component of the construction industry is material, therefore the firm needs to know the repercussions of proper materials management techniques on the success of completion of the project. Poor management of materials on the construction sites can lead to significant adverse effects with cost and time overrun. Therefore the present study aims to explore current practices in construction materials management, to identify the problems in construction materials management also to optimize the material cost by applying different inventory control techniques. This paper describes the importance of materials management on the construction site. The present study contains literature related to the basic components of materials management, attributes of materials management, materials management practices and their applications. Also, few studies have been carried out on an effective procurement process of materials management in the construction industry. A short introduction to inventory control techniques such as ABC analysis, EOQ analysis, S-curve analysis, HML analysis, SDE analysis, VED analysis and FSN analysis are also discussed in this paper.*

***Key Words*: Construction industry, Materials management, Importance, Process, Inventory control techniques, Cost optimization.**

## 1. INTRODUCTION

Construction projects such as housing, infrastructure facilities utilize a large number of construction materials. Also, there is ever increasing demand for growth in the construction industry hence, researchers try to find out a superior solution for effective materials management. Kumar et al. (2018) observed that construction materials constitute 55% to 60% of the total budget allocated for construction works. Therefore, efficient procurement and handling of materials during construction activities represent the main role in the successful completion of the project. As per Okorocha (2016), materials management is the line of responsibility that begins with the selection of suppliers and ends when the material is delivered to its point.

According to Subramani et al. (2017), materials management is defined as the process of planning, procuring, providing and storing the appropriate material at the right place, at the right time and in the right quantity to minimize the overall cost of the project. The project manager should always consider that ineffective procurement of materials may be a potential cause for delay. Problems related to materials on the construction site includes; failure to order materials on time which delays the projects, delivery at the wrong time which disturb the work schedule, over-ordering of materials, wrong arrival of materials and double handling of materials, etc. This emphasizes that it is very essential to have a materials management department to support the management in the various activities going on construction sites. It also helps in the control of all the types of materials for their quantity, quality and cost.

## 2. LITERATURE REVIEW

In this paper, a literature review related to an overview of materials management in the construction industry and the various inventory control techniques for the optimization of material cost is studied. For this, various technical papers and reports have been referred for the understanding of various concepts, theories and methodology for research work. Out of various literature, some of the studied research articles and their brief introduction are given below.

### 2.1 Basic components of materials management

As per Kulkarni et al. (2017), the four basic components of materials management are; Purchasing, Material Handling and Transportation, Receiving and inspection, Storage and warehousing. Those components are shown in Figure 1 and further described.

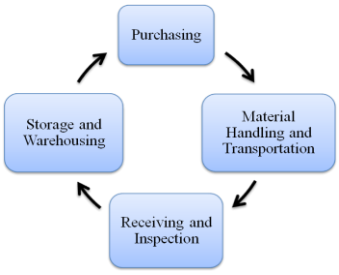


**Fig. -1:** Basic Components of materials management (Kulkarni, et al., 2017)

As shown in Figure 1, purchasing is equivalent to inventory list that purchase department makes for procurement of materials and send it to the selected supplier. In the process

of material handling and transportation, as shown in Figure 1, long and heavy materials such as steel columns, reinforcement bars, precast concrete blocks, bricks and cement bags deserve careful handling both offsite and onsite. Receiving and Inspection ensures quality control, a proper record of the number of materials received and inspected of their qualities, security of expenditure, etc. Some materials require storage within an enclosed storeroom to safeguard the material against loss, theft, damage, etc. Hence, experienced staff is needed to perform the activities of storing and warehousing materials (Refer to Figure 1). Also, good storage practice ensures that materials to be used early are kept closer to the store entrance.

### 2.2 Objectives of materials management

The primary objectives of materials management in any project are supply, storage and control of the incoming materials to ensure that the optimum cost is obtained from the expenditure incurred with the materials. The secondary objectives include forecasting, product improvement, standardization, make or buy decisions, quality control, etc. The primary and secondary objectives of materials management listed in Table 1 contributes to achievement of company goals.

**Table -1:** Objectives of materials management (Ashika, 2019; Patel and Patel, 2017)

| Sr. No | Primary objectives | Secondary objectives |
|---|---|---|
| 1 | Right price | Forecasting |
| 2 | High turnover | Product improvement |
| 3 | Low procurement and storage cost | Standardization |
| 4 | Continuity in supply | Make or buy decision |
| 5 | Maintaining consistency in quality | New materials and product |
| 6 | Good relationship with suppliers | Inter departmental harmony |
| 7 | Development of personnel | Quality control |
| 8 | Good information system | Material handling |
| 9 | Efficient material planning | Efficient product scheduling |
| 10 | Good record keeping | Development of reciprocal relations with suppliers |

### 2.3 Importance of materials management

As per Jadhav et al. (2017), emphasis the importance of materials management in the construction industry by stating that the operational efficiency of any project is directly associated with materials management. Following are the few ways which show the importance of materials management.

- Materials management practices reduces storage of materials on site.
- Materials management helps to improve the labor productivity.
- Management of materials at the site is important for improvements in a project schedule.
- The efficient management of materials emphasis better relations with supplier.
- Materials management helps the companies to increase their efficiency of activities to remain competitive in the current market conditions.
- Materials management at site emphasis better cash flow management.

### 2.4 Materials management problems

As per Toor and Ogunlana (2008), an important problem that negatively affects the performance of construction projects is the ineffective management of materials during the construction activity. Inappropriate handling and management of materials on the construction sites can delay the project performance.

According to Navon and Berkovich (2005), the major problems of materials arriving at the site are late arriving of materials at the site, wrong ordering of materials, materials that do not match the purchase order, forgetting to order materials, information regarding the status of the orders is not available, lack of complete and up-to-date information regarding the arrival of materials to the site, surplus of materials and waste of man-hours searching for materials and tracking them.

In large organizations, material manager ensures that an accurate quantity of material is ordered ensuring materials those are needed, use of inventory control techniques like ABC analysis, HML analysis, EOQ analysis, etc to decide the place and proper time for the delivery of materials. During the construction phase, one of the most challenge is tracking materials. Automated systems like Bar Codes, Radio Frequency Identification (RFID) Technology, Information and Communications Technology (ICT) improve tracking and inventory control. Mehr and Omran (2013) found that the lack of user-friendly software packages and the lack of capable personnel in using computer-based materials management systems are considered the main difficulty in construction materials management.

### 2.5 Effective process of materials management

Jadhav et al. (2017) have made an attempt to study the effective process of materials management as shown in Figure 2. It includes material generated from the site according to the specifications. After that indent is prepared then whether the material is available or not at the site is checked by the supervisors. Material stock is also checked at the warehouse. The vendor providing most effective cost of the required material is selected from the approved list. Then the material is ordered from the store after that material is received and inspected to ensure correct material as per the specifications. The inspected material is then issued to the department. This overall process is termed effective materials management (Refer to Figure 2).


**Fig. -2:** Effective process of materials management (Jadhav, et al., 2017)

### 2.6 Factors affecting materials management

Vipin and Shabeen (2019) found that the factors affecting materials management at the construction site is always connected with certain risk factors which are different for different projects. These risk factors should be considered by the project manager to finding out the uncertainty of the project. Kebede and Patel (2018) describe the major factors affecting materials management are given below;

- Rework due to errors occurred during construction activities.
- Cash flow problems due to late and reduced payments.
- Late delivery of construction materials.
- Improper handling of materials during construction activities.
- Material price escalation.
- Poor planning, controlling and monitoring of material.
- Difficulties in finding out client's desires, changes of client's requirements, long procedures to discuss changes.
- Change of orders due to enhancement required by clients.
- Inaccurate data, engineering drawings not fitting the use excessive quantity during construction.
- Deliveries of material not in correspondence with planning, wrong and defective deliveries, long storage period, etc.

## 3. Selective inventory categories and criteria

The work done by Nanaware and Saharkar (2017) found that inventory classification is very important to manage inventory at construction site. For inventory optimization and inventory forecasting, products need to be classified properly. For this purpose techniques such as EOQ analysis, ABC analysis, S-curve analysis, VED analysis, HML analysis etc. are developed for qualitative and quantitative analysis. These different techniques are shown in Figure 3 and further described.

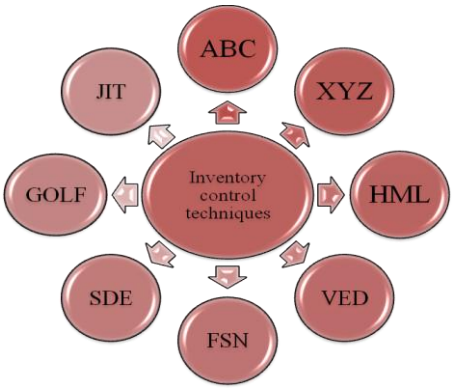


**Fig. -3:** Different inventory control techniques (Pandya, and Thakkar, 2016)

The criterion used for the analysis of different techniques as shown in Figure 3 are annual usage value, criticality, lead time, unit cost, consumption rate, procurement difficulties, etc. (Refer to Table 2). Selective inventory control has been divided into 8 categories. The following Table 2 shows the various types of inventory control techniques along with their respective criteria and applications.

**Table -2:** Selective inventory control categories, criteria and application (Brindha, 2014).

| Sr. No. | Category | Criteria | Application |
|---|---|---|---|
| 1 | ABC analysis | Annual usage value | Material which go in to the production |
| 2 | XYZ analysis | Inventory investment | A category status |

| Sr. No. | Category | Criteria | Application |
|---|---|---|---|
| 3 | HML analysis | Unit price | To keep check on high cost items |
| 4 | VED analysis | Criticality of production | For controlling spare parts of inventory |
| 5 | FSN analysis | Dispose non-moving inventory | For controlling obsolescence |
| 6 | SDE analysis | Source of procurement | To keep watch on availability of materials |
| 7 | SOS analysis | Seasonality | Should buy in harvest season to get price advantage |
| 8 | GOLF analysis | Source of procurement | Canalizing agency can be used |

### 3.1 ABC analysis (Always Better Control)

According to Kebede and Patel (2018), ABC analysis is a widely used inventory control technique and popularly known as Always Better Control or the alphabetical approach has universal applications in many areas. According to Madhavi et al. (2013), ABC analysis is the most popular inventory control technique adopted as Pareto's Law. The following Table 3 shows rational limits for ABC classification of items in percentage with their number of items and number of annual sales revenue. From Table 3, it is observed that about 20% of the number of items that account for about 80% of the total consumption value are called 'A' items, about 30% of the number of items that account for about 15% of the total consumption value are called 'B' items and about 50% of the number of items that account for about only 5% of the total consumption value are called 'C' items.

**Table -3**: ABC classification(Plinere and Borisov, 2015)

| Category | No. of items | No. of annual sales revenue |
|---|---|---|
| **Class A items** | About 20% | About 80% |
| **Class B items** | About 30% | About 15% |
| **Class C items** | About 50% | About 5% |

### 3.2 EOQ (Economic Order Quantity)

The main categories of costs in EOQ are procurement cost and holding cost. These costs are exactly opposite to each other, as these two costs are opposite, an innovative model is required to make a balance between them.

Kumar et al. (2018) defined EOQ is an inventory-related model which is used to obtain the optimum order quantity that can be purchased to reduce the cost of both the carrying inventory and the processing of purchase orders. Procurement costs incurred by obtaining items such as costs for communicating order, costs for supplier selection, transportation costs, etc. Holding costs i.e. carrying costs represent the costs incurred on holding the items. It includes storage costs, spoilage costs, insurance, taxes, etc. According to Onwubolu and Dube (2016), the EOQ model addresses two important questions; (I) when to order and (II) how much to order. Patel and Patel (2017) have given the formula to calculate EOQ (Refer Equation 1) and order frequency (Refer Equation 2).

$$1.\quad EOQ = \sqrt{(2 \times D \times S / H)} \qquad .....(1)$$

where,
EOQ = Optimal order quantity
D = Demand per year (units)
S = Re-order cost/ Procurement cost (/purchase order)
H = Carrying or holding cost (/unit /year)

$$2.\quad n = D/EOQ \qquad .....(2)$$

where,
n = Numbers of order per year
D = Demand per year (units)
EOQ = Economic order quantity

### 3.3 S-Curve analysis

The S-curve is stated as "a graph of cumulative costs or labor hours plotted against time". The S-curve analysis is used to track the growth of the project. As per Patel and Patel (2017), S-curve analysis is formulated for the variation observed between the planned and actual material consumption on the site. This analysis allows the project manager to quickly identify the growth of the project also, slippage and potential problems that could adversely impact the project.

### 3.4 SDE analysis (Scarce, Difficult, Easy)

The criterion used for this analysis is the availability of the materials in the local market. The information obtained from SDE analysis is used to decide procurement strategies. The SDE analysis represents three levels of classification groups called 'Scarce', 'Difficult' and 'Easy'.

**Scarce -** Scarce classification of material includes items that are in short supply and imported through government agencies. Generally, these items are raw materials, spare parts and imported items.

**Difficult -** D item stands for difficult items. These D items are not easily available in the local market and have to be procured from distant places. For these D items, there is a

limited number of quality suppliers are available in the market and those suppliers are difficult to get.

**Easy -** Easy classification covers those items which are readily available and locally found in the market. Items produced to commercial standards and items where supply exceeds demand fall into this group.

### 3.5 HML analysis (High, Medium, Low)

In HML analysis, materials vary in terms of their prices and 'Price' criterion is used for the classification purpose. The items under HML analysis are classified into three groups that are 'High', 'Medium' and 'Low'. To classify the items under H, M and L category, they are tabulate in the descending order of their unit price. The organizational reviews and voting decides the criteria for categorizing those items. According to Jadhav and Jaybhaye (2020), HML analysis helps the manager to decide on buying policies which mean H and M items should not be ordered more than required quantity because they consume high price. Kumar et.al. (2016) have given the percentage based classification for the H, M and L classes;

- **H Class item -** These are costly item and are generally 10% to 15% of the total item.
- **M Class item -** These items are low cost item as compared to H class items and these are generally 20% to 25% of the total item.
- **L Class item -** These items are low class items and generally 60% to 70% of the total items.

### 3.6 FSN analysis (Fast moving, Slow moving, Non moving)

According to Mitra et.al. (2015), in construction industry, some materials are quite regularly required, yet some others are required very occasionally and some materials may have become obsolete and might not have been demanded for years together, therefore FSN analysis is used to groups these items into three categories as Fast-moving, Slow moving and Non-moving.

It is found that many companies maintain huge stocks of non-moving items blocking quite a lot of capital hence, FSN analysis is used to identify those surplus items i.e. non-moving items. FSN analysis is also used to identify active items which have to be reviewed on a regular basis.

### 3.7 VED analysis (Vital, Essential, Desirable)

The VED analysis is specially used for maintenance spare parts and denotes the essentiality of stocking spares. When non-availability of fewer valuable items become very critical then VED analysis plays an important role hence, the VED analysis is done to determine the criticality of an item. The VED analysis stands for 'Vital', 'Essential' and 'Desirable'.

**Vital -** These are items without which the project comes to a standoff. i.e. non-availability of material cannot be tolerated. For these items, a large stock of inventory is maintained.

**Essential -** The items whose non-availability can be tolerated for 2 to 3 days because similar or alternative items are available in the market. These are the items without which temporary losses are occurs.

**Desirable -** These are items whose non-availability cannot be tolerated for a longer period of time. For D items, minimum stock is enough. Desirable items do not cause any instant loss in production.

## 4. CONCLUSIONS

- From the studied literature it is found that, rather than focusing on the theoretical models, synergetic and practice-based approaches such as ABC analysis, EOQ analysis are found more economical and beneficial to the construction firms.

- From the literature study, it is observed that the most of the research carried out through inventory control techniques are limited to residential projects only. Very few studies are carried out for infrastructure projects.

- Through the literature survey, it is concluded that organization can follow EOQ for optimum purchase of material and can maintain safety stock in case of delay of material. Also, there should be tight control over A Class materials based upon ABC analysis. The S curve analysis should be done to check the variation in the planned and actual progress of work to avoid the delay of the project. If we could accurately carry out and follow all the techniques of inventory management, we will be able to maximize the profit with minimum cost and these techniques also help in the continuous production flow.

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