LECTURE SEVEN: MATERIAL PROCUREMENT AND DELIVERY

The main sources of information for feedback and control of material procurement are requisitions, bids and quotations, purchase orders and subcontracts, shipping and receiving documents, and invoices. For projects involving the large scale use of critical resources, the owner may initiate the procurement procedure even before the selection of a constructor in order to avoid shortages and delays. Under ordinary circumstances, the constructor will handle the procurement to shop for materials with the best price/performance characteristics specified by the designer. Some overlapping and rehandling in the procurement process is unavoidable, but it should be minimized to insure timely delivery of the materials in good condition.

The materials for delivery to and from a construction site may be broadly classified as : (1) bulk materials, (2) standard off-the-shelf materials, and (3) fabricated members or units. The process of delivery, including transportation, field storage and installation will be different for these classes of materials. The equipment needed to handle and haul these classes of materials will also be different.

Bulk materials refer to materials in their natural or semi-processed state, such as earthwork to be excavated, wet concrete mix, etc. which are usually encountered in large quantities in construction. Some bulk materials such as earthwork or gravels may be measured in bank (solid in situ) volume. Obviously, the quantities of materials for delivery may be substantially different when expressed in different measures of volume, depending on the characteristics of such materials.

Standard piping and valves are typical examples of standard off-the-shelf materials which are used extensively in the chemical processing industry. Since standard off-the-shelf materials can easily be stockpiled, the delivery process is relatively simple.

Fabricated members such as steel beams and columns for buildings are pre-processed in a shop to simplify the field erection procedures. Welded or bolted connections are attached partially to the members which are cut to precise dimensions for adequate fit. Similarly, steel tanks and pressure vessels are often partly or fully fabricated before shipping to the field.

In the construction industry, materials used by a specific craft are generally handled by craftsmen, not by general labor. Thus, electricians handle electrical materials, pipefitters handle pipe materials, etc. This multiple handling diverts scarce skilled craftsmen and contractor

supervision into activities which do not directly contribute to construction. Since contractors are not normally in the freight business, they do not perform the tasks of freight delivery efficiently. All these factors tend to exacerbate the problems of freight delivery for very large projects.

The process flow of material procurement is given below

1. Determination of requirement
2. Source determination.
3. Vendor selection and comparison of quotations.
4. Purchase order processing.
5. Purchase order follow up
6. Goods receiving and inventory management.
7. Invoice verification.

Material provisioning process:

1. Study contract documents to identify items of purchase.
2. Estimate quantities to be purchased.
3. Float inquiry indents to locate sources of supply.
4. Invite quotations from selected vendors.
5. Analyse quotations received and vendors pre-qualification.
6. Submit proposal for technical, financial and client approval.
7. Negotiate with vendor and finalise supply order.
8. Place purchase order and monitor order execution.
9. Conduct pre-shipment inspection.
10. Inspect goods received at site.
11. Close material supply contract.

Materials to be provisioned =Theoretical quantity of materials x {(100+standard wastage in %)/100}

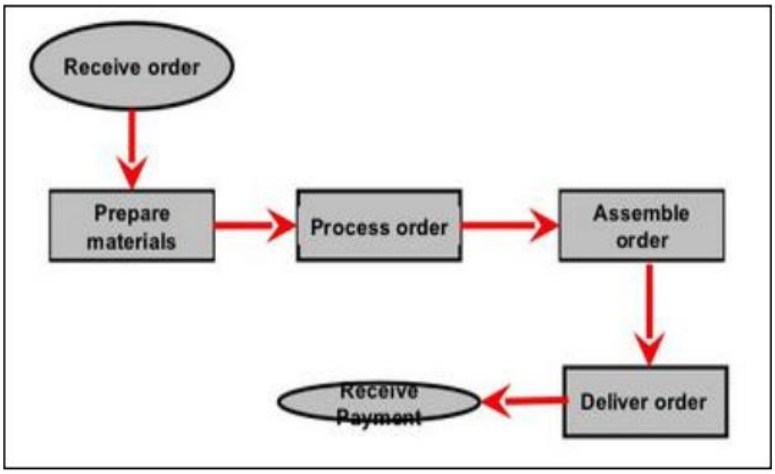
The contents of delivery plan information is given below:

1. Warehouse
2. Transportation of materials
3. Delivery receiver
4. Safe unloading of materials at site

5. Site conditions
6. Access to vehicle
7. Inspection before unloading

Monitoring Material Delivery Schedule:

1. Preparing and monitoring material sample approval, procurement plan.
2. Conduct pre transportation inspection.
3. Obtain periodic information on shipment.
4. Keep documents ready for clearing customs during transportation.
5. Plan for receiving materials-unloading place, machinery for handling materials, person for inspection and storage arrangement.
6. Inspecting and intimating the deviations to management for replacement or reorder.



Flowchart showing delivery process

INVENTORY CONTROL:

Once goods are purchased, they represent an *inventory* used during the construction process. The general objective of inventory control is to minimize the total cost of keeping the inventory while making tradeoffs among the major categories of costs: (1) purchase costs, (2) order cost, (3) holding costs, and (4) unavailable cost. These cost categories are interrelated since reducing cost in one category may increase cost in others. The costs in all categories generally are subject to considerable uncertainty.

Purchase Costs

The *purchase cost* of an item is the unit purchase price from an external source including transportation and freight costs. For construction materials, it is common to receive discounts for bulk purchases, so the unit purchase cost declines as quantity increases. These reductions may reflect manufacturers' marketing policies, economies of scale in the material production, or scale economies in transportation. Unit prices of materials depend on bargaining leverage, quantities and delivery time. The transportation costs are affected by shipment sizes and other factors.

Order Cost

The *order* cost reflects the administrative expense of issuing a purchase order to an outside supplier. Order costs include expenses of making requisitions, analyzing alternative vendors, writing purchase orders, receiving materials, inspecting materials, checking on orders, and maintaining records of the entire process. Order costs are usually only a small portion of total costs for material management in construction projects, although ordering may require substantial time.

Holding Costs

The *holding costs* or *carrying costs* are primarily the result of capital costs, handling, storage, obsolescence, shrinkage and deterioration. Capital cost results from the opportunity cost or financial expense of capital tied up in inventory. Handling and storage represent the movement and protection charges incurred for materials. Storage costs also include the disruption caused to other project activities by large inventories of materials that get in the way. Obsolescence is the risk that an item will lose value because of changes in specifications. Shrinkage is the decrease in inventory over time due to theft or loss. Deterioration reflects a change in material quality due to age or environmental degradation. Many of these *holding cost* components are difficult to predict in advance; a project manager knows only that there is some chance that specific categories of cost will occur. In addition to these major categories of cost, there may be ancillary costs of additional insurance, taxes (many states treat inventories as taxable property), or additional fire hazards. As a general rule, holding costs will typically represent 20 to 40% of the average inventory value over the course of a year.

Unavailability Cost

The *unavailability cost* is incurred when a desired material is not available at the desired time. In manufacturing industries, this cost is often called the *stockout* or *depletion* cost. Shortages may delay work, thereby wasting labor resources or delaying the completion of the entire project. Again, it may be difficult to forecast in advance exactly when an item may be required or when a shipment will be received. While the project schedule gives one estimate, deviations from the schedule may occur during construction. Moreover, the cost associated with a shortage may also be difficult to assess; if the material used for one activity is not available, it may be possible to assign workers to other activities and, depending upon which activities are critical, the project may not be delayed.

Inventory is defined as complete list of items such as property ,goods in stock or contents of a building.

The stages of inventory include

1. Raw materials
2. Work in progress
3. Finished goods

Inventory management system

Methods of Inventory Control:

1. ABC analysis

   A-Always B-Better C-Control

   In this inventory is classified based on importance

   - A-High cost
   - B-Average cost
   - C-Low cost

2. VED analysis

   In analysis is used for spare part management. It is based on price and availability of spare parts.

   - V-Vital
   - E-Essential
   - D-Desirable

3. FSN analysis

   It is based on the movement of goods in market

   - F-Fast moving goods
   - S-Slow moving goods
   - N-Non moving goods

4. SDE analysis

   This analysis is based on availability of goods in market.

   - S-Scarce items
   - D-Difficult
   - E-Easily available items

5. HML analysis

   This analysis is based on unit value of items

   - H-High value
   - M-Medium value
   - L-Low value

Inventory costs:

1. Ordering cost (C_o)
2. Carrying /holding costs (C_h/ C_c)

Ordering cost = C_o x (D/Q)

Holding cost = C_h x (Q/2)

Where

D – Annual demand

Q-Order size

**Total inventory cost = { C_o x (D/Q)}+{ C_h x (Q/2)}

Economic Order Quantity (EOQ) or (Q^*):

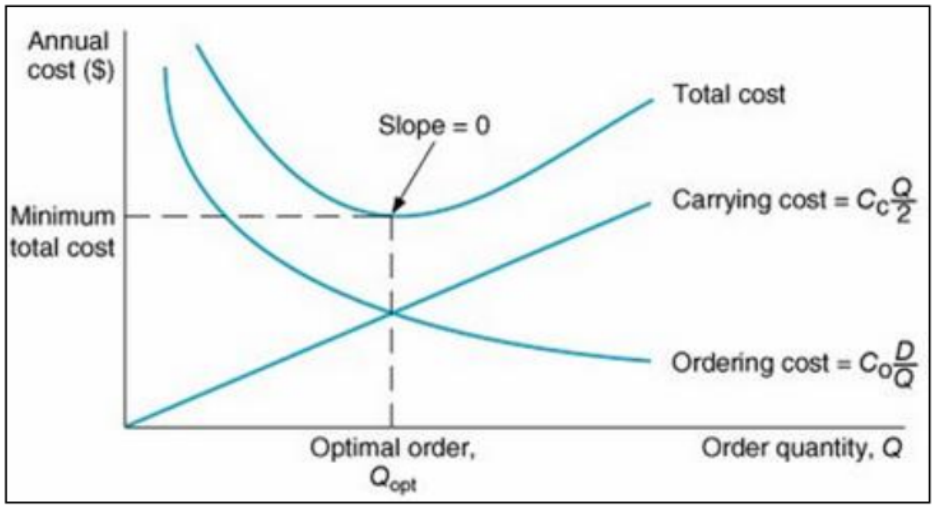
It is the optimal quantity of orders that minimizes total variable cost required to order and hold inventory.

Assumptions:

1. Demand is uniform, constant and continuous over time.
2. Lead time is constant.
3. No limit on order size.
4. Cost of placing an order is independent on size of order (No discount available).

EOQ cost curve:

Cost curve is obtained by plotting order quantity along x axis and cost along y axis. Optimal order Q_{opt} is also called Economic Order Quantity (EOQ). It is also denoted as Q^*



EOQ cost curve

To find Q^*

Total inventory cost = { C_o x (D/Q)}+{ C_h x (Q/2)}

Differentiating with respect to Q and equating to 0

0= {- C_o x(D/Q^2)}+{ C_h/2}

$$Q^*=\sqrt{(2\ C_oD/\ C_h)}$$

Total minimum cost = { C_o x (D/Q^*)}+{ C_h x (Q^*/2)}

Illustration:

1. A company produces 450 bicycles per month. It buys tyres for bicycle from a supplier at a cost of Rs.20 per tyre. The company's inventory carrying cost is estimated as 15% of unit cost and ordering cost is Rs.50 per order. Calculate
   a. EOQ
   b. Number of orders per year
   c. Average annual ordering cost
   d. Average inventory
   e. Average annual carrying cost.
   f. Total cost.

Solution:

a. D=(2 tyres per cycle)x450x12

D=10,800 tyres.

C_o=Rs.50

C_h=15% of Rs.20 =Rs.3 per unit per year.

$$Q^*=\sqrt{(2\ C_oD/\ C_h)}$$

Substituting

Q^*=600 tyres

b. Number of orders (N)=D/Q
   =10800/600
   =18 orders per year.
c. Average annual ordering cost
   =18 orders x Rs.50 per order
   =Rs.900 per year
d. Average annual carrying cost
   =Average inventory x C_h
   =300x3
   = Rs.900 per year.
e. Total cost
   =ordering cost +carrying cost
   =900+900
   =Rs.1800