Module - V

Concept of materials management - inventory - inventory control Economic order quantity - ABC analysis - Safety in Construction - Safety measures in different stages of Construction - Implementation of safety programme

The term 'materials' is used in general sense and refers to the whole range of goods and services that are purchased or otherwise procured from sources outside the organisation and are used or processed in order to provide finished products for sale. One can notice a fundamental difference in materials management in a factory-like situation and a construction project-situati

Material management is the integrated functioning of the different sections of a company dealing with the supply of materials and other related activities so as to obtain maximum co-ordination and optimum expenditure on materials.

Scope of material management is vast as

- It begins with "arrival of contract"
- And ends with "material resting at its point of use".

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Objectives of material management:

(1) Minimise material cost

(2) Procure and provide material of desired quality when required

(3) Reduce investment tied in inventories for use in other productive purposes and to develop high inventory turn over ratios

(4) Purchase, receive, transport and store material efficiently and to reduce the related costs

(5) Cut down costs though simplification, standardisation value analysis, import substitution etc

(6) Modify paper work procedure in order to minimise delays in procuring material

(7) Train personnel in the field of materials management in order to increase operational efficiency.

(8) In large construction organisation, for performing material management function, there is a material management department which is headed by a vice president and he or she is supported by a general manager.

(9) The general manager is overall in charge of central material dept and regional material dept.

The responsibilities of central material department :-

(1) To procure high value materials centrally for different regions

(2) To arrange for their transport to respective regions

(3) To exercise inventory control
(4) To enter into rate contract for frequently used construction materials such as cement, steel, plywood at organisation level.
(5) To develop computerised procedures
(6) To procure capital equipments and to arrange for their maintenance.
(7) To supply raw materials to company's manufacturing units.
(8) To import construction materials depending on the requirement of projects
(9) To gather MIS (Management Information System) reports and their analysis.
(10) To standardise and codify the construction material
(11) To dispose of the waste and scrap materials

People involved in the material procurement process:

(1) In large construction organisation, the project manager is responsible for material management.

(2) The planning engineer and the materials engineer are responsible for preparing the materials schedule, sending the requisition for the materials, monitoring and control of materials consumption at projects, comparing the tender provision and actual cost of materials and so on.

(3) The quality engineer is responsible for sampling and testing of materials recieved at project sites and also for checking their conformance with the specification

(4) The stores in charge is responsible for follow-up with the vendors, recieving and issuing the eight materials and so on.

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Material Management Functions:

1. Material planning
2. Procurement
3. Custody
4. Accounting
5. Transportation
6. Inventory monitoring and control
7. Codification
8. Computerisation

1. Material planning

The site planning engineering is responsible for this function. He makes a purchase requisition in consultation with the construction manager, following which the material is procured by administrative people. Materials schedule should be the basis ofor raising material requisitions.

Material planning involves:

→ Identifying materials
→ Estimating quantities
→ Defining specifications
→ Forecasting requirements
→ Locating right sources for procurement.

2. Procurement

Before procurement, the site planning engineer along with the materials engineer survey the local market and identify the items that are to be procured locally and those are to be procured from the head office under centralised procurement system. Local procurement should be kept the minimum and limited to non engineered items and consumables.

Advantages of centralised and local purchasing:

Centralised:

- Low unit price due to large volume of purchase
- Smoother purchasing action due to well-laid out process.

- Specialised person having better market knowledge involved in the process
- Dealing with regular suppliers and hence better negotiated price

Local

- Faster response to material requirement for the project
- Better project control and regulated expense towards purchasing expenses.

Advantages and disadvantages of early procurement:

Advantages:

(1) Materials availability is assured and hence work will not suffer.

(2) Proper quality and price of materials can be assure as there is time to look around and shop.

Disadvantages:

(1) Material may be stolen or may deteriorate during storage

(2) Materials will require space for storage, which may be also be needed for other uses.

(3) They needed to be guarded and accounted for.

(4) Money locked up in the purchase of materials does not get interest and other works may suffer due to this.

Advantages and disadvantages of late procurement:

Advantages:

- All the disadvantages of early procurement are avoided

Disadvantages

- All the advantages of early procurement are lost
- If guaranteed delivery dates are available, it may be satisfactory to arrange for deliveries to be made a week in advance of the starting date of the work.

3. Custody (Recieving, Warehousing and Issuing):-

The main documents used are;

- Inward register, material reciept note (MRN), delivery challan (DC), indent, dispatch covering note, Outward register, loan register, repair register and plant and machinery movement register

The functions of warehousing are;

- Cover receipt, inspection, storage, issue/dispatch, materials accounting, valuation and insurance.

4. Materials accounting

Purpose of materials accounting

- Monitoring inflow and
- Consumption of raw materials

Material accounting involves;

- Material stock accounting
- Material issues and returns accounting
- Monthly stock taking of selected materials and
- Materials wastage analysis

Material wastage analysis aims at finding the causes of wastages and rectifying them. Wastage during procurement can result from various factors;

- Buying materials of wrong specification
- Buying more than the actual requirements
- Unnecessary buying of items to cater for unrealistic and unforeseen eventualities.
- Untimely buying of short life materials
- Improper and unnecessary handling of materials
- Wastage while transportation.

Other reasons for wastage includes.

(1) Breakages and damages during handling
(2) Lack of pre-work preparation and co-ordinator
(3) Inferior quality of materials
(4) Improper accounting and poor store keeping
(5) Negligent and careless attitude of supervisor
(6) Unforeseen circumstances like accidents, fire etc
(7) High rate of deterioration due to long storage at the place of work.
(8) Over issues from the central stores and

(9) Failures to return unused surplus materials
(10) Thefts and pilferage

5. Transportation:

Construction materials used at site should be transported from their point of origin to storage point and then to actual point of consumption. In some cases materials may be received at central stores and then dispatched to project stores at site and finally to work place. Proper care should be taken while planning for transportation of raw materials and semi finished materials so as to avoid any adverse effect on the characteristics or performance of materials.

6. Inventory monitoring and Control :-

→ Inventory may be defined as usable but idle resource and if resources is some physical and tangible object such as material then it is called stock.

→ Inventory level should be frequently monitored and controlled for better performance

→ Scientific inventory management is an extremely important problem area in material management function

→ Material accounts for more than half the total cost of any business and organisations, maintain a huge amount of stocks

→ Inventory is highly amenable to control, it is a symptom of poor performance.

→ Inventory can be reduced by proper design of procurement policies by reduction in uncertainties of lead times by variety reduction and in many other ways.

Need for inventory:-

→ Improves customer service.

→ Permits purchase and transportation economies - both product procurement and transportation cost will be reduced if lot sizes are large

→ Hedges against price changes - one can observe the tendency to hoard commodities in anticipation of price rise just before the budget.

→ Protect against demand and lead uncertainties. When there are uncertainties in the customer demand patterns and the suppliers replenishment lead times, it is preferable to invest in safety stock so that the services are maintained at acceptable level at customers

→ Hedges against contigencies.

Inventory Control Methods:

- ABC analysis
- FSN analysis
- VED analysis

Functions of inventory:-

- To meet anticipated demand
- To smooth production requirements
- To decouple operations
- To protect against stock-outs
- To take advantage of order cycles
- To help hedge against price increases
- To permit operations
- To take advantage of quantity discounts.

7 Materials Codifications:-

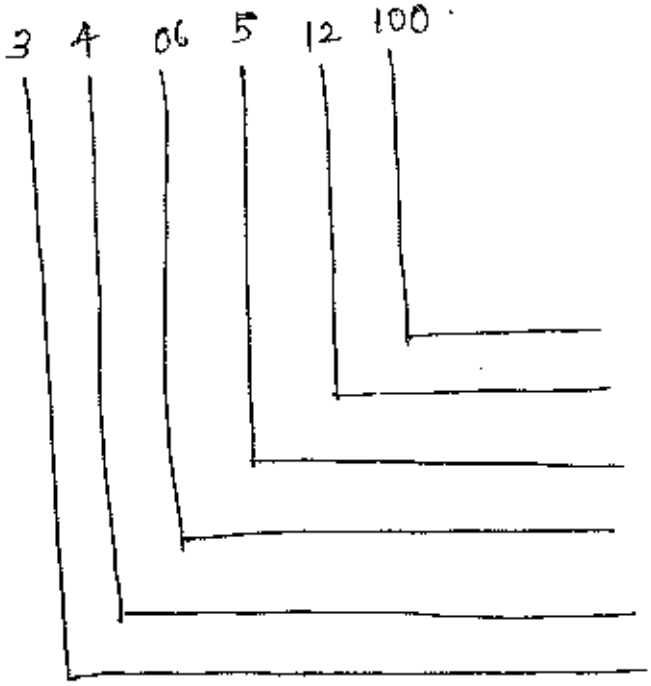
→ Important function in materials management
→ Especially used by construction companies where thousands of different items are used all along the project duration

→ Different systems of codification
- Numeric codification
- Alphanumeric codification
- Colour codification

Numeric codification:- Numbers are used

Eg:- Material code: 3406512100

1st digit represents - class of material
2nd digit represents - major group of materials
3rd represents - minor group
4th digit represents - metal
5th digit represents - diameter
6th digit represents - length



Alphanumeric Codification :- Both letters and numbers are used.

Normally used for equipment and spare parts is

9 C B 6 2 0007

1st digit represents class (Eg:- Spares)

2nd digit represents equipment category (eg:- Concreting equipment)

3rd digit represents equipment name (eg:- Batching machine)

4th digit represents the make of equipment (eg:- Schwing stetter)

5th digit represents equipment model (eg:- 56 m³)

6th digit represents serial number coding of parts

Proper system of material codification serves for following purposes:

(1) Proper identification of items by all departments concerned.

(2) Avoiding use of long description of items

(3) Material accounting and control

(4) Avoiding duplicate stocks under different descriptions

(5) Ensuring receipt and issue documents are posted in appropriate record.

(6) Helps in mechanisation of records.

(8) Material Computerisation:

Computers are being increasingly used in the application of Construction materials management.

Functions of Material Computerisation :-

→ Forecasting the prices of materials based on past data and analysing past trends

→ Planning of different materials - Using the construction schedule, one can work out the materials schedule quite easily using computers.

→ Developing the specification of materials - One can refer to past specifications stored in the computer make.

suitable adjustments depending on the requirements of the project.

→ Purchasing of materials - It is now possible to enquiries for different materials online as well as invite bids from different suppliers online

→ Preparing a comparative statement and finalizing the supplier.

→ Inventory control -

✓ Computers can play an important role in decision making as far as economic order quantity is concerned.

✓ An inventory analysis using different methods can be easily performed using computers.

Inventory Control :-

The term inventory means the value or amount of material or resource on hand. It includes raw material, work-in-process, finished goods and stores and spares. Inventory control is the process by which inventory is measured and regulated according to predetermined norms such as economic lot size for order or production, safety stock, minimum level, maximum level, order level etc. Inventory control pertains primarily to the administration of established policies, systems

and procedures in order to reduce the inventory cost

Objectives of inventory control :-

(1) To meet unseen future demand due to variation in forecast figures and actual figures
(2) To average out demand fluctuations due to seasonal or cyclic variations
(3) To meet the customer requirement timely, effectively efficiently, smoothly and satisfactorily
(4) To smoothen the production process
(5) To facilitate intermittent production of several products on the same facility
(6) To gain economy of production or purchase
(7) To reduce loss due to changes in prices of inventory items
(8) To meet the time lag for transportation of goods
(9) To meet the technological constraints of production process
(10) To balance various costs of inventory such as order cost or set up cost and inventory carrying cost
(11) To balance the stock out cost / opportunity cost due to loss of sales against the costs of inventory
(12) To minimise loses due to deterioration, damage etc.

Factors affecting inventory control:-

(1) Type of product
(2) Type of manufacture
(3) Volume of production

Benefits of inventory control:-

(1) Ensure an adequate supply of materials
(2) Minimises inventory costs
(3) Facilitates purchasing economy
(4) Eliminates duplication in ordering
(5) Better utilisation of available stocks
(6) Provides a check against the loss of materials
(7) Facilitates cost accounting activity
(8) Enables management in cost comparison
(9) Locates and disposes inactive store items
(10) Consistent and reliable basis for financial statements.

Inventory Control Methods

Technique of maintaining the size of inventory at some desired level keeping in view the best economic interest of an organisation.

ABC - Based on forecasting accuracy.
VED - Vital, Essential, Desirable demand.
FSN - Fast, Slow and Normal consumption
HML - High, Medium and Low unit price
XYZ - classify material in storage.
SDE - Scarce, difficult and easy to procure
GOLF - Government, Ordinary, Local and Foreign procurement strategy
HML - High, Medium and Low price

ABC Analysis:

This is based on 'Pareto's Law, which says that in any large group there are 'significant few' and 'significant many'. For example only 20 percent of the items may be accounting for 80% of the total material cost procured by a construction organisation. These 20% constitute 'significant few' that require utmost attention.

To prepare an ABC-type curve, we may follow a simple procedure:

(1) Different materials required for the project are identified and their estimated quantities worked out. The quantity estimate could be on the basis of either annual consumption or the project's total requirement.

(2) The unit rates of materials are estimated.

(3) The usage values of each of the materials are obtained by multiplying the estimated quantities and their unit rates. These values are converted to % of total annual usage cost or total project cost, as the case may be.

(4) The percentage usage cost for each of the materials is arranged in the descending order of their ranking, starting with the first rank, i.e. highest to lowest usage value. The cumulative percentage usage value is also calculated.

(5) A curve is plotted, and points on the curve at which there are perceptible sudden changes of slopes are identified. In the absence of such sharp points, cut off points corresponding to the top 10% and the next 20% or so are marked as a general indicator A, B and C type of materials.

(6) According to an empirical approach, 'A' class items account for about 70% of the usage value, 'B' class items for about 20% of the usage value, 'C' class items for about 10% of usage value. In terms of numbers, 'A' class items constitute about 10% of total items, 'B' class items about 20% of total items and 'C' class items about 70% of total items. These percentages are indicative only and can vary depending on a number of factors.

Upon classification of materials into A, B and C types suitable inventory policies can be decided. Corresponding to each type of materials, the implications on inventory policy are mentioned below:-

Item type 'A' The salient features are:

→ Accurate forecast of quantities needed.
→ Involvement of senior level of purchasing
→ Ordering is on requirement basis.
→ Enquiries for procurement need to be sent to a large number of supplies
→ Strict degree of control is required, preferably monitoring on a weekly basis
→ Low safety lock is needed.

Item type 'B': Salient features are:

→ Approximate forecast of quantities needed.
→ Requires involvement of middle level of purchasing
→ Ordering is on EOQ basis
→ Enquiries for procurement needed to be sent 3-5 reliable supplies
→ Moderate degree of control required, preferably maintaining on a monthly basis
→ Moderate safety stock needed.

Item type 'C': The salient features are

→ No need of forecasting, even rough quality estimate is

sufficient

→ Junior level staff is authorised to order purchase

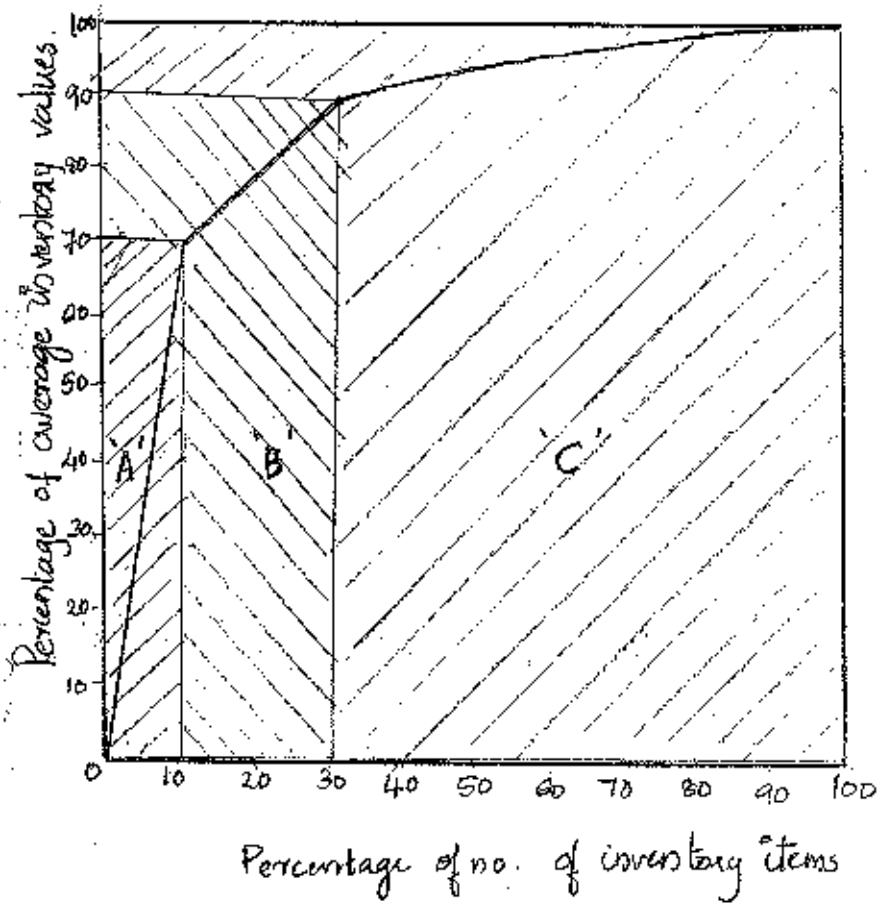
→ Bulk ordering is preferred.

→ Quotations from even 2 or 3 reliable suppliers are sufficient.

→ A relatively relaxed degree of control is sufficient, and monitoring can be done on a quarterly basis

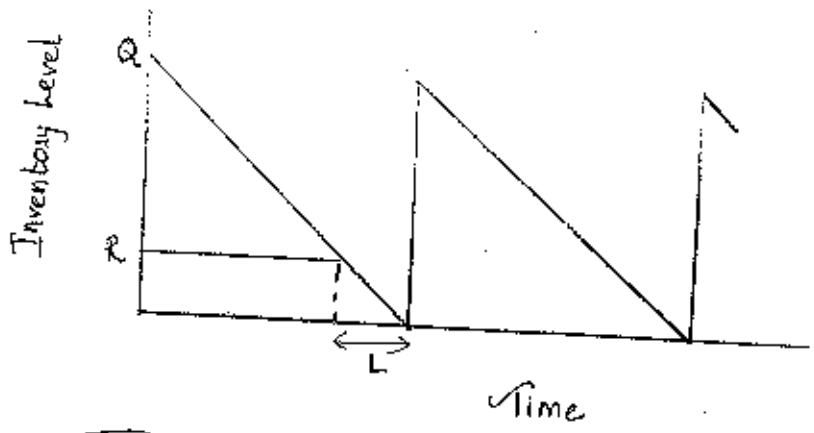
→ Adequate safety stock can be maintained.

Illustration of ABC analysis.



Inventory Models:

There are a number of computer based analytical inventory models available (such as economic order quantity [EOQ] model), most of which are able to generate economic purchase orders, shipping orders, delivery notes and invoice. Most models claim to improve management control by reducing inventory-holding costs without loss of customer service. The basic philosophy behind these models is to use a trade-off analysis by comparing the cost of inventory holding versus the cost of ordering.



Inventory behaviour under EOQ model.

Economic Order Quantity (EOQ) Model

The EOQ model provides answers on how much to order. The reorder point R and the quantity to be ordered, Q are shown in the figure, as is the lead time L. The ordered quantity derived from this model is known as economic order quantity, EOQ.

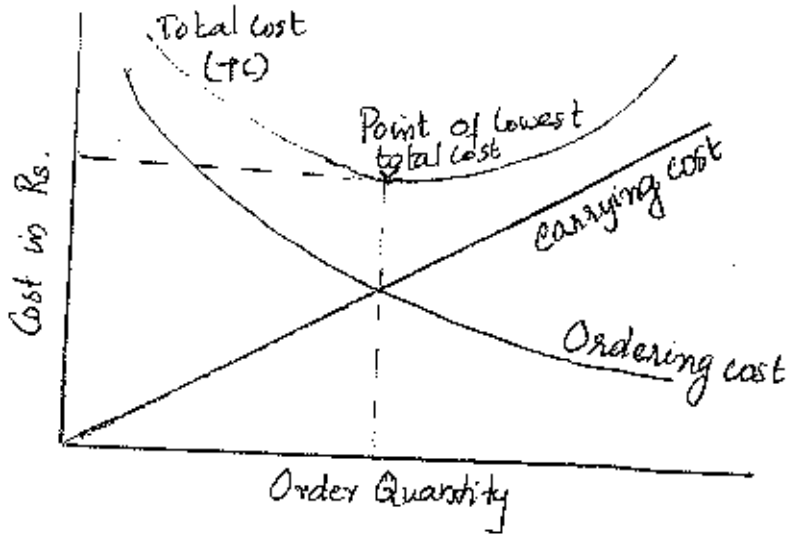
It is usually less expensive to purchase (and transport) or produce a bunch of material at once than to order it in small quantities. If orders for large quantities are specified, there will be fewer orders placed. For purchasing, this means that quantity discounts and transportation efficiencies may be realized. The other side of the coin, however is that larger lot sizes result in more inventory and inventory is expensive to hold. EOQ model attempts to specify a balance between these opposing costs. This aspect is shown graphically in figure, while there is increase in cost with increase of inventory.

The total cost is given by the sum of inventory carrying cost and ordering cost.

Total cost TC = Ordering Cost + Carrying Cost

The following notations are used to develop the EOQ model:

D = Demand rate; unit/year
A = Ordering cost; Rs/order.
C = Unit cost; Rs/unit of item
I = Inventory - carrying charges per year.
H = Annual cost of carrying inventory/unit
Q = Order quantity; number of units per lot



Total cost curve in EOQ Model

It is assumed that demand is at a uniform rate. Thus the average inventory required would be $\left(\frac{0+Q}{2}\right) = \frac{Q}{2}$ throughout the year.

The total numbers of orders placed would be $\frac{D}{Q}$ per year

Order cost per year = Number of orders placed per year × Cost per order

Ordering cost per year = $\frac{A \times D}{Q}$

Carrying cost per year = $\frac{\text{Order quantity} \times \text{Unit cost of item} \times \text{Annual cost to carry}}{2}$

Carrying cost per year = $\frac{C \times I \times Q}{2} = \frac{H \times Q}{2}$

where

$H = C \times I$.

Using the notations mentioned above, we can write the expression of TC as:

$$TC = \frac{A \times D}{Q} + \frac{H \times Q}{2}.$$

For optimum Q, one needs to find the particular value of Q which will minimise total cost. This can be done by differentiation, and one gets:

$$EOQ = \sqrt{\frac{2 \times \text{Order cost} \times \text{Demand}}{\text{Inventory carrying cost}}}$$

$$EOQ = \sqrt{\frac{2 \times A \times D}{I \times C}}.$$

Some of the observations that are clear from the above expressions are:

(a) The more the demand per year, the larger the order quantity.

(b) The higher the order cost, the larger the order quantity.

(c) The more expensive the item, the smaller the order quantity.

(d) The higher the carrying cost, the smaller is the order quantity.

The derivation of EOQ is based on a number of assumptions such as:

(1) Demand is deterministic and continous at a constant rate

(2) The process continues infinitely

(3) No constraints are imposed on quantities ordered, storage capacity, budget etc

(4) Replenishment is instantaneous (the entire order quantity is received all at one time as soon as the order is released).

(5) All costs are time-invariant

(6) There are no shortages of items

(7) The quantity discounts are not available

(8) There is negligible or deterministic lead time

The above assumptions mean that there is no uncertainty and one is able to predict the demand and the constancy of cost parameters such as item cost, carrying rate or ordering cost. In real life, however all these assumptions may not hold good.

In case the lead time is varying, one has to keep safety stock or buffer stock. Normally the service level that is expected will decide the safety stock. If one keeps a very small quantity as safety stock, there is a danger that stock out may occur. On the other hand, large safety or buffer stock may result in large inventory carrying cost. Thus safety

stock will be decided based on the service level desired. The following relations are important and should be noted.

(a) Reorder point = Demand or usage per period × Lead time

(b) Average Inventory Carried = $\frac{\text{Order quantity}}{2}$ + Safety stock

(c) Transit Inventory = Days in transit × Inventory carried per day

(d) The higher the lead time, the more will be the safety stock and vice versa. In general, the safety stock varies with the square root of lead time (assuming all other factors as constant). For example, if the lead time for an item is reduced by a factor of 4, then the safety stock will be reduced by a factor of 2 (ie $\sqrt{4}$).

Effect of uncertainty in demand:

Generally, demand is never uniform all throughout the year. In case, the demand has a mean of D_m and standard deviation σ_d, the reorder point is expressed as given below:

$$\text{Reorder point} = (D_m \times \text{Lead time}) + (Z \times \sigma_d \times \sqrt{\text{Lead time}})$$

(Where Z is the standard normal variate for a given service level. In order to find the value of Z, one can use normal distribution table provided. The service level is the probability of having material in stock when demand of this material occurs in a construction project.

Values of Z for different service levels

Service level	90%	92%	94%	95%	96%	98%	99%
Z	1.29	1.41	1.56	1.65	1.75	2.05	2.3

Safety in Construction { Construction Engg & Management of Projects — S.C. Sharma.

Construction sector is one of the major industry of the world. The construction activities range from construction of rural house to multi-storied framed structures, for village roads to express highways, docks and harbours to airports, thermal power houses to major hydro electric projects. Safety represents most important concern for the construction projects which results in increased cost and delays besides personal injuries or even fatalities. Construction is a high hazard occupation and workers involved are exposed to safety and health hazards. Severity of each hazard depends on the concentration and duration of exposure of a particular job.

Construction is an accident and injury prone sector due to various reasons such as nature of work, difficulty in implementation of safety measures due to scattered work and seasonal employement. The accidents occur because of:

(1) Lack of training
(2) Breach of rules and regulations including non implementation and slackness.
(3) Overwork/ overtime by workers and.
(4) Negligence/non alertness.

Implementation of many projects are sometimes adversely affected due to unsafe operations and working conditions causing accidents, environmental pollution, health hazard, damage to buildings and other structures, property and machinery. Such safety hazards occur due to various reasons, some of which are given below:

1. Negligence on the part of workers or supervisory staff
2. Faulty operations
3. Exposure of harmful substances.
4. Accidental fall from a height
5. Flash flood in bridge construction in hilly areas.
6. Sudden subsidence of overhead structures
7. Inflow of flood water in underground operations
8. Accident with construction equipment.
9. Earthquake, severe storm, tornado or cyclone.
10. Failure of forms, scaffolds, ramps, ladders etc.

It has been observed that most accidents can be avoided through the application of an effective safety programme. To combat the health hazards and accidents, a qualitative change in the area of safety and health management is needed during implementation of a construction project. A three fold strategy of action should be undertaken, which consist of

(a) An efficient accident prevention programme
(b) Immediate attention in case of accident

(c) Comprehensive plan for rehabilitation of victims

Implementation of Safety Programme

Lack of training has been identified as one of the major causes of accidents. Safety awareness is the basic requirement for reducing accidents. Most of the accidents take place due to adoption of short cuts and/or ignoring the safety guidelines. There is a need to prepare project safety manual (PSM) which should include a set of minimum safety standard and guidelines which are expected to be followed on any construction project. The manual should include the mandatory use of personal protection equipment, safety awareness training programmes, fire protection, first-aid, safety signages, accident reporting procedure.

Following are the main objects of safety programmes (also known as accident prevention programme):

(i) To reduce the human life sacrified
(ii) To lessen the temporary and permanent injuries to workers.
(iii) To reduce the time lost due to accident
(iv) To safeguard against loss of or damage to equipment and properties.

(v) To control the expenses on workmen's compensation

Safety programme should be made an integrated part of the operations of each Construction company. An effective programme should be developed to suit the particular operation such as excavation, pile driving, drilling and blasting, tunnelling etc. Each operation has its own hazards and safety programme should be developed to suit the particular hazards.

Safety programme in Construction industry, must recieve the full support of an entire organisation, beginning with top management and continuing down through the ranks to include the project managers, supervisors and workers.

In any safety programme, following are essential:

1. Secure full support of top management
2. Designate one person in the organisation to direct safety programmes.
3. Give publicity to the safety programmes.
4. Develop a safety programme for each job
5. Install safety programme, creating the competition with appropriate rewards for outstanding performance.
6. Train new employees with the safety programmes.

7. Safety practice be made effective
8. Promote good house - keeping
9. Maintain adequate first aid facilities
10. Seek assistance from insurance Companies

Now-a-days, safety committees are formed including executives, supervisors and workers. This also helps in creating safety consciousness. Safety programme analyses cause of accidents and takes remedial measures. Safety peogramme is a continous proces Spcial training are imparted to emplogees on safety aspects.

In order to create awareness, safety week are organised, safety instructions are displayed. It is also necessary to make necessary safety rules and enforce them.

Safety education and training :-

There should be proper facilities to impart training in safety measures to the workers. This can be accomplished by safety posters, safety films safety contests and suggestions. These are useful to increase the interest of emplogees in accident prevention. The purpose of this training is to induce care in the use of dangerous tools or in carrying out risky opeeations.

Employees should be made aware of exposure to possible harm or injury in their work environment, including physical, chemical, electrical, ergonomic, radiation, biological and psychological hazards. The management should also ensure that adequate safe training is provided by the contractor to his personel.

Safety promotional activities should be organise periodically to create awareness among the employees. Such activities should include organising safety da Safety week, fire safety day, fire safety week, safety competition, posters, slogans, safety calendars and displa depicting possible consequences of unsafe acts and condition in the project area.

The construction projects should develop training programme after the assessment of current capabilities. Training programmes should be designed to address the needs of different target groups such as:

(a) Senior management (b) Supervisors.
(c) Workers (d) Those having specific responsibilities like first aid, fire, health etc

SHE training should be provided at certain key-times in an operational cycle including:-

(i) At induction for new employees.
(ii) When employees are transferred to new jobs

(iii) On movement into managerial or supervisory positions
(iv) On engagement of sub-contractors
(v) When modification in the system / procedure is carried out, and
(vi) After a time gap, as a refresher training

Safety Manual:

Every construction company is required to prepare a detailed safety manual complying with the statutory requirements (including Building and Other Construction Workers Act, 1996 and Rules there of) manufactures recommendations, BIS (Bureau of Indian Standards) standards and any other relevant standards and codes.

The safety manuals should at least cover the following safety aspects:-

1. Safety policy
2. Safety organization
3. Responsibilities of senior exautives, employees, contractors and safety officers.
4. Reporting accidents
5. Enquiry of accidents / dangerous occurances.
6. Enforcement of safety regulations
7. Occupational health and medical facilities
8. Emergency management plan.

9. Location of safety equipment and emergency facilities in the project
10. Safety inspection / audits
11. Safety training, awareness and promotion
12. Hazard identification and risk assessment
13. Personal protection equipment (PPE)
14. Communication facilities
15. Fire prevention and protection
16. Emergency escapes routes
17. Safe working environment
18. Rescue team
19. Protection against hazardous chemicals / gases
20. Safety in various works in the project
21. House keeping
22. Fencing of rotating machinery
23. Traffic management and safety on public roads
24. Prevention of un-authorised entry
25. Safety in quarries and borrow-areas
26. Safety measures to minimise the effects of mishaps resulting on account of geological surprises

for HOD

29/11/19

18
Safety Measures In Construction Work

18.1. INTRODUCTION

After independence the construction industry has grown significantly. The construction industry in India to day is very large in size and complex in nature. In Civil Engineering projects many works big or small are executed. For the execution of these works skilled and unskilled labour along with machines and equipments are employed. With the introduction of machines for increasing the output of the work, the number of accidents also is increasing. It is a hard fact that where the safety ends, accidents start. Any work completed with out accidents results economical. No body wants to be injured, but it happens so sudden that one can not help. On the one hand accidents cause injury to the worker and agony to his family and on the other hand, they cause mental tension and financial burden to the owner.

Though the social concern of the safety of construction workers and their protection against injury is quite evident since long, but so far no tangible results have been observed. The survey of occupational injury and illness incidence carried out in 1982 shows that upto 14.5% workers suffer from these injuries. The break up of occupational injury in different industries is shown in Table 18.1.

Table 18.1. Occupational injury rate

S. No.	*Industry*	*% of total injury*
1.	Finance, Insurance etc.	2.0
2.	Services	4.9
3.	Whole sale and retail trade	7.2
4.	Agriculture, forestry	7.7
5.	Transportation utilities	8.5
6.	Manufacturing	10.2
7.	Mining	10.5
8.	Construction	14.5

18.2. DEFINITION OF ACCIDENT

An unplanned and unexpected occurrence which upsets the planned sequence of events and actions, resulting in the loss of production, injury to the person and damage to plants and equipment is known as accident.

18.3. IMPORTANCE OF SAFETY

In India the construction industry is labour oriented. It employees the largest labour force after agriculture. The injury rate is found about 10.0 to 14.5% of all the occupational injuries and about 20% deaths. The cost of accident is very expensive. The economic cost is not the only criteria for taking safety

measures. Actually the reasons for safety considerations are as follows:

1. Humanitarian reasons. The sufferings and agony undergone by the injured worker and his family members is difficult to quantify in economic terms. Thus accidents should be prevented more on humanitarian considerations.

2. Economic reasons. The accidents have their own costs, which include direct and indirect costs. Direct cost includes.

(*a*) Medical expenses for the injured
(*b*) Compensation amount to the injured
(*c*) Legal charges
(*d*) Cost incurred in replacement of equipment and damaged materials etc.

Indirect Costs. These costs include:

(*a*) Slow down in progress of work
(*b*) Productive time lost by the injured worker and fallow workers
(*c*) Decrease in productivity due to moral decrease after injury
(*d*) Over time payment to make up the loss of time
(*e*) Loss of confidence by the client etc.
(*f*) Loss of administrative work due to accident.

3. Organisational image. Good safety measure record boosts the morals of the workers resulting in higher productivity and better loyalty of the workers to the organisation. Good safety measures will also enhance the public image of the organisation.

4. Laws and Regulation. The employer has to adhere to the laws and regulations laid down by the Government for the safety of the employees. The violation of these laws and regulation will attract punishment to the employer.

18.4. CAUSES OF ACCIDENTS

In construction industry there are many causes of accidents. Broadly the causes of accidents may be classified as follows:

A. Physical causes
B. Physiological causes
C. Phychological causes

A. Physical causes

Under the head physical causes following factors may be grouped:

1. Relating to machines
2. Relating to tools
3. Relating to materials
4. Relating to uniform
5. Relating to environment
6. Fixing unsuitable time table etc.

1. Causes Relating to machines. Under this head following causes may be classified:

(*a*) The working space for the machines may be inadequate. Due to obstruction free movement of man and material is not possible, which may cause accidents.
(*b*) The machines not being properly placed or adjusted
(*c*) Unsuitable machines being used for the job
(*d*) The machines not being properly guarded
(*e*) The electric motor of the machine not properly insulated

This may also be called as defective technical planning.

2. Causes relating to tools

(*a*) Due to constant use, the tools being blunt and worn out
(*b*) Tools employed on the job being too small for the job
(*c*) Tools used may be of brittle nature and break suddenly, for example blades of a circular saw

(*d*) The handle of the tool may be too short or loose
(*e*) Tools used may be unsuitable for the job

2. Causes relating to materials.
(*a*) Materials used may be poisonous and dangerous as acids and some salts etc.
(*b*) The materials may be too hot as tar or bitumen at the time of use of road construction and no proper precautions taken
(*c*) Explosives, petroleum products and brittle materials being handled carelessly.
(*d*) Not adopting proper precautions while cleaning sewer etc. which emit foul gases.

4. Causes relating to uniform.
(*a*) The uniform may be loose
(*b*) The shoes may be slippery and loose
(*c*) No protective device being used while working on welding job
(*d*) The sleeves of shirt being with out buttons

5. Causes relating to environment
(*a*) Poor lighting arrangement at the site of work
(*b*) Poor ventilation and unhygienic conditions at the site of work
(*c*) Uninsulated wires left carelessly
(*d*) Loose electric cables
(*e*) Obstacles in the working area
(*f*) Floor being sleepry
(*g*) Building used being unsafe
(*h*) Use of unsuitable *i.e.* weak or short ladder
(*i*) External disturbances as noise
(*j*) Loose discipline among workers

B. Physiological causes

This factor relates to the health conditions of the workers. Accidents due to this factor are grouped as follows:

(*a*) *Poor eye sight.* This a very important factor for every worker, especially for the workers handling machinery, automobiles and cranes etc. If a driver can not see an vehicle or obstacle ahead clearly especially in poor visibility conditions will result in accident.
(*b*) *Over work.* A tired worker due to over time, loses control over his limbs easily and may meet accident.
(*c*) *Poor health.* A worker due to poor health may not control his load of work and may meet an accident.
(*d*) *Old age.* Generally in old age eye sight becomes poor and also one becomes hard of hearing along with poor general health. These factors cause accidents easily.
(*e*) *Intoxication.* One loses control over his limbs and becomes prone to accident under the influence of intoxication.
(*f*) *Physical handicapness.* A physical handicap person is more prone to accidents.

C. Physchological factors

Under this head, the factors causing accidents are related to mental condition of a worker:
(*a*) *Mental tension and worry.* Under mental tension and worry one loses control over his mind and may meet an accident.
(*b*) *Emotional attitude.* An emotional person loses mental balance quickly.
(*c*) *Impulsiveness.* When a person acts under impulse, with out proper thinking, the chances of accidents are more.

(*d*) *Nervousness.* A nervous person loses control over his limbs quickly and has more chances of meeting an accident.

(*e*) *Over confidence.* Many a times over confidence results in accidents.

(*f*) *Carelessness.* A care less worker has more chances of meeting a accident than a conscious worker.

(*g*) *Fear.* Under fear also one loses control over his limbs quickly.

18.5. OBJECTIVES OF ACCIDENT PREVENTION

The main objective of prevention of accidents is to save human lives, equipment, and materials etc. Accident prevention results in:

1. Saving of human lives.
2. Prevention of temporary or permanent injury to workers
3. Prevention of damages to plants and equipment, and loss of materials.
4. Saving in the cost of compensation to workers.
5. Saving in loss of time due to injury.

18.6. CLASSIFICATION OF ACCIDENTS IN CONSTRUCTION INDUSTRY

The accidents in construction industry may be classified as follows:

1. According to the cause of occurrence
2. According to the nature of injury sustained as
   (*a*) Temporary disablement (*b*) Partial disablement
   (*c*) Total disablement (*d*) Death
3. According to the severity of injury as
   (*a*) Minor accident (*b*) Major accident (*c*) Accident hazard

18.7. SAFETY MEASURES

During the construction of a project, safety is also influenced to a great extent by the decisions taken during the planning and design processes. Some designs or construction plans are inherently difficult and dangerous to implement, where as others may considerably reduce the possibility of accidents. For example clear separation of traffic from construction zones can greatly reduce the possibility of accidental collisions. Besides design decisions, safety largely depends upon the education and training of workers, vigilance and cooperation during construction.

Choice of proper technology, and machines can also reduce the chances of accidents to a great extent. Proper choice of materials also influence the safety of construction.

Educating managers and workers about proper procedures and hazards has been found to have a impact on the safety at job site. The realization of the large costs involved in construction injuries and illness provides an motivation for safety.

18.8. SAFETY MEASURES REQUIRED IN CONSTRUCTION AREAS

Usually safety measures are required in the following areas of constructions

1. Excavation
2. Scaffolding, ladders and form work
3. Hot bitumen work
4. Demolition works
5. Drilling and blasting works

1. Safety measures in excavation work

In the construction of Civil Engineering works such as buildings, dams, bridges etc. excavation work for foundations etc. is one of the important activities. If during excavation operations proper safety measures are not adopted, it may cause serious accidents. Some basic principles of safety measures are discussed below:

(a) General guide lines:

(i) Before starting excavation work, complete information of under ground structures such as water pipe lines, sewers, gas lines, electric cables etc. is essential. All safety measures should be adopted to ensure the safety to the workers and the public.

(ii) The work should be entrusted to an experienced and competent supervisor. He should be made responsible for strict observance of safety precautions.

(iii) The excavated trenches should be given proper protection against slides and caving in during and after heavy rains and storms etc.

(iv) Workers should be asked to wear helmets, where there is danger of falling stones etc.

(v) Constant watch and supervision should be kept on new workers, while engaged on jobs involving risk or hazards.

(b) Precautions to be taken while working with machines:

In construction industry to increase the productivity, the use of machines and equipment is increasing day by day. Hence it is very important to take necessary precautions while using machinery and equipment. following precautions should be adopted while working with machines.

(i) *Proper selection of machinery.* The excavating machinery should be selected properly depending upon the size of project and nature of soil to be excavated.

(ii) *Upkeep of the machinery.* The servicing and over hauling of the machinery should be carried out regularly by qualified persons. The maintenance and up keep of the machinery should be carried out regularly and the machines should be kept upto date.

(iii) *Operation of machinery.* For operating the machines only qualified persons should be appointed. Un qualified or unauthorized persons should never be allowed to handle the machinery as they are bound to have an accident.

(iv) Mentally and physically fit persons only be allowed to work on machinery.

(v) Faulty machines should not be pressed in operation.

(vi) Dangerous parts of the machines such as chain drive, belts etc. should be provided with proper cover.

(vii) While running the engine, replacement of oil, lubrication, or repair work should not be under taken.

(viii) While starting the machine, the operator should give a working signal and no body should be allowed to stand under the boom or raised part of the machine. Machine should not be left running.

(ix) After stopping a movable machinery, its driving wheels should be bracked.

(x) One should not jump into or from a moving vehicle or equipment.

(xi) While working in night, proper lighting arrangements must be ensured.

(xii) Work should not be executed partially by machines and partially by manual labour as it is likely to meet an accident.

(c) Shoring and timbering of excavated trenches:

(i) *Vertical cut trenches.* In medium soils the trenches more than 1.5 m deep should be securely shored and timbered. In case of hard soils, timbering is necessary if the depth of cutting exceeds more than 2.0 m. Sheathing is placed against the sides of the trench with planks held vertically. In loose soils the sheathing is firmly embedded into the bottom of the trench.

(ii) Loose boulders, lumps of earth etc. should be removed, so that they may not roll down into the trench and injure the workers.

(iii) The excavated material should be removed away back ward from the edge of the trench at least 1 m or more. Actually the excavated material should be removed to a distant place. If this is not practicable then boards should be provided to prevent the rolling down of the soil into the

trench. Tools used in construction should also be kept away from the edge of the trench for similar reasons.

(*iv*) Vehicles should not be allowed to be driven close to the edges of the trench. While loading excavated soil into the trucks, care should be taken that loose soil does not roll down into the trench.

(*v*) The path ways and gang ways should be non slippery and of sufficient width. Planks used for gang ways should be provided with cleats to ensure safe walking.

(*vi*) If traffic passes near the trenches, strong fencing should be provided to prevent animals and public from falling into the trenches. To ensure safety of pedestrians and vehicles, the public walk sides should be lighted sufficiently. At both ends of the area under excavation red lights should be provided. Warning signals should also be placed.

(*vii*) Persons required to work under deep trenches or at high altitudes, safety ropes should be tied to their safety belts, so that they could be helped at the time of need. A single worker should never be allowed to work in a trench alone.

(*viii*) It should also be ensured that no harmful gases are present in the trenches. If they are present then appropriate mechanical ventilation should be provided to protect the life of the workers.

2. Scaffolding

(*i*) It is required for all types of structures constructed above ground level and maintenance of such works. The type of scaffolding to be used depends upon the nature of the work and its situation.

(*ii*) The vertical standards should be embedded into the ground sufficiently deep, so that they may withstand the loads coming on them. On pucca floors and streets these standards may be placed into the empty tar drums and packed with stones and bricks etc.

(*iii*) Various stages of construction may be erected at convenient heights.

(*iv*) While connecting ledgers to standards and putlogs to ledgers, lashing should be done securely. The rope used should be thick and stout.

(*v*) The sizes of different members should be properly designed according to the load they are supposed to carry.

(*vi*) To safeguard against over turning, inclined rakers are provided and lashed at the junctions of standards and ledgers at appropriate height and embedded into the ground at the bottom.

(*vii*) The boarding over which the mason sits, should be of sufficient width and strength to take up the load of workers and building materials needed for immediate use. Proper guide rails should be provided so that mason and workers may not fall.

(*viii*) To avoid the risk of its sliding, the putlog should be inserted sufficiently deep in the wall.

(*ix*) No body should be allowed to stand below the scaffolding, as stones or bricks may fall down from the scaffolding and injure the person standing below.

(*x*) As the scaffoldings are not designed to carry large quantity of building materials, only small quantity of materials should be put on the scaffolding.

(*xi*) When the work is over, the scaffolding should be dismantled step by step from upper side. Its members should be stacked on the hard ground. They should not be stacked against wall. This will avoid sagging and warping of the members. To avoid crack development they should not be exposed to direct sun rays.

(*xii*) Before using scaffolding members second time and subsequently, they should be tested for strength. Wooden members should be free from wet and dry rot.

(*xiii*) For repair work at high level of multistoyred buildings needle scaffolding is preferred as it will not obstruct traffic at the ground level.

(*xiv*) In sheds for ceiling works, suspended scaffolding is economical. It also does not occupy floor space, allowing workers to continue their work at ground level.

(xv) Workers should not be allowed to lit fire near the scaffolding.

1. 8. Ladders

(a) General. In any construction activity, ladders constitute one of the essential part of construction equipment. If proper attention is not paid to this aspect, it may result in many accidents.

(b) Causes of accidents. The accidents may occur due to the following causes:

(i) Failure to secure properly ladder at top or bottom or at both places
(ii) Ascending or descending improperly
(iii) Structually failure of the ladder itself
(iv) Unsafe conditions of placing the ladder
(v) Carrying load carelessly while ascending or descending.

(c) Construction of ladder

(i) All ladders should be designed for the loads they are intended to carry.
(ii) Side rails for metal ladders should be of sufficient cross- section so that excessive deflection may not develop into them.
(iii) In bamboo ladders, the rungs should be fixed to the rails with spikes of proper design and strength. In other types of wooden ladders, the use of spikes or nails should not be allowed.
(iv) To avoid danger of slipping, safety shoes should be used.

(d) Built-up ladders

(i) In case of built-up ladders all surfaces of the ladder should be planed free from splinters, and the edges of hand rails should be bevelled.
(ii) The rungs should be spaced uniformly and should not be spaced more than 30 cms apart. They should be recessed at least 12mm into the rails.
(iii) Ladders used for heavy work, should not be more than 6 m long, where as for light work, the length may be upto 8 m.

(e) Portable ladders

(i) The over all length of stock ladders should not be more than 10 m. The minimum internal width of ladders should be 29 cms for ladders upto 3 m length. For longer ladders this width may be increased by 6 mm for every additional length of 0.3 m.
(ii) In case of metal, ladders, rungs must be made of steel pipe or solid round steel rods or angle sections, securely fastened to the side rails by bolting, riveting or welding. The metal treads should be flanged downwards not less than 50 mm at each end and secured to each side rail by two bolts or rivets. Dimension of the ladder should be adopted as per IS specifications.

(f) Use of ladders

1. Portable ladder. While using portable ladder following points should be kept in mind.

(i) Before use all ladders should be tested for the designed load. The ladder should be strong and rigid.
(ii) A defective ladder with missing rung, should never be used. Efforts should be made to repair it promptly.
(iii) The splicing of ladder should be avoided.
(iv) Ladder leading to lending should be extended at least one metre above the landing and secured at the upper end properly.
(v) Ladders should not be supported against window panes, sashes, or other unsafe or yielding objects. They should also not be placed infront of door opening towards it. When the ladders are used in public walk ways, suitable barricades should be provided.
(vi) While using ladder, one should not lean sideways more then 30 cms. It is safer to get down and shift the ladder to the new place.

(*vii*) While ascending or descending, the user should face the ladder. He should use his both hands and place his feet near the end of the rungs and not in the middle.

(*viii*) To prevent slipping, a ladder should be placed in such a way that it does not make an angle of more than 75 degree with the ground *i.e.* the distance between the vertical wall or face and the lower and of the ladder should not be more than one fourth of the length of ladder or ladder should be secured at the bottom properly.

(*ix*) Metal ladder should not be used around electric circuit or equipments.

(*x*) Extension ladders should be used up 10 m length. To ensure proper locking and full extension of the section, locks and guides should be checked properly.

(*xi*) The diameter of rope ladder should not be less than 25 mm and wooden steps should not be less than 38 mm thick.

(*f*) Inspection and storage of ladder

(*i*) If the ladder damaged or dropped while in use, it should be inspected carefully.

(*ii*) For damage or deterioration, wooden ladders should be inspected at least once a month.

(*iii*) The metal ladders should be inspected at least once in three months. All parts should be checked for structural failure and corrosion etc.

(*iv*) The wooden ladders should be treated with a clear preservative such as varnish.

(*v*) The ladders should be stored in covered space, where they may not be affected by direct sun rays, or rain. To avoid sagging in storage they should be supported adequately.

2. C. Form work

(*i*) Form work may be either of steel or timber. In case of timber form work, the timber used should be of coarse grained, so that nails may be driven easily with out causing damage to the timber. Timber should be free from knots and other defects.

(*ii*) The section of timber should be such that may be capable to bear the pressure of green concrete. The weight of green concrete may be taken as 2400 kg/m^3.

(*iii*) To make the timber form work water resistant, it should be provided G.I. sheet lining. The provision of sheet lining prevents the loss of water from the concrete and provides smooth surface to it.

(*iv*) The construction of form work should be such that it can be dismantled or removed easily, with out causing any harm to the concrete or form work it self, as it has to be used a number of times on future works.

(*v*) To provide smooth surface to concrete and to avoid damage to it as well as form work, the interior surface of form work should be given a thin coating of either grease, oil or such other material. To allow sags in beams the form work should be given a camber of 1 in 5.

Precautions to avoid shrinkage, bending and warping under loads

To avoid bending, warping and shrinkage under loads following precautions may be adopted:

(*i*) Partially seasoned timber should be used for form work. If dry timber is used for form work, allowance for bulging, and shrinking should be provided while preparing the surface.

(*ii*) Now a days for shuttering, water proof plywood is used. Plywood should conform to the Indian standard. It should be durable under alternate wetting and drying conditions. Its surface should be hard and sufficiently strong to take the load of concrete and impact during the placement of concrete and compaction.

(*iii*) To ensure economy, the sizes of members of the form work should be standardised, so that it could be used again and again. The design of structure and form work should be done simultaneously.

(iv) To provide facility at the time of removing and reusing of the form work, the use of clamps and screws is preferable.
(v) As the form work is to be used for a number of times, it should be removed very carefully with out causing any damage. It should be stacked in such a way that there is maximum circulation of air. The stacking should be done in such a way that bending, warping and cracks etc. are not developed in members. Members should not be kept inclined against walls, as this will cause bending in them. Wet members should not be exposed to hot sun.
(vi) Unauthorised persons or stray cattles should not be allowed near the form work as any damage to the form work may prove dangerous.
(vii) The reinforcement cage should not be laid in position with a jerk, but should be placed gently.
(viii) Concrete in the form work should not be thrown from a height of more than 1 m as it will damage the form work, displace the reinforcement from its position. It may also cause segregation in concrete.
(ix) Before the reuse of form work, its members should be checked carefully. Damaged members should not be reused. It should be free from dry rot and wet rot.
(x) Steel form work is more economical as it can be used for more number of times than timber form work. It is more safe and gives better concrete surface.
(xi) Concreting in the form work should be started after it has been inspected and checked by approved competent authority.
(xii) At the time of removing form work, no body except workers on the job should be allowed near the site of work as any falling member may cause injury.
(xiii) The form work should be removed with out any jerk or vibration as it may cause damage to the reinforced concrete. Before removing the bottom form work of the slab or beam, it should be ensured that the bottom surface has hardened sufficiently. Actually form work should be removed as per ISI recommendations.

3 Hot bitumen works

(i) The tar boilers should be equipped with suitable temperature recording device. The bitumen or tar should not be allowed to be over heated. By over heating the binding properties of tar are destroyed and with further heating it may catch fire. To keep constant temperature bitumen should be constantly stirred.
(ii) Only trained and experienced workers should be deputed for bitumen work.
(iii) Only physically fit and mentally alert workers should be engaged on the bitumen works.
(iv) The work should be planned in such a way that workers are given rest at suitable interval.
(v) The workers should be provided with protective wear. It should be ensured that every worker is wearing tarring outfit for his safety.
(vi) Workers should wear Goggles to avoid damage to eyes from funes of hot bitumen.
(vii) Work should be stopped during stormy weather. It will safeguard against fire hazards.
(viii) When the wind is blowing fast, bitumen spaying should be done carefully. It should not be done against the direction of the wind.
(ix) Warning signals such as sirens must be kept ready at the site of work and must be sounded promptly in case of fire hazards.
(x) Fire fighting equipment also be kept ready at the site of work.
(xi) First aid box and some trained persons in first aid also be available at site of work.
(xii) At both ends of the road under construction, sign boards indicating, "bitumen work is in progress" must be displayed.
(xiii) To check the entry of road users in the portion under construction, it should be protected from all sides by keeping empty drums and proper diversion should be provided.

(*xiv*) At a time only half width of the road should be constructed and the other half should be allowed to be used by road users.

(*xv*) To divert the traffic, proper barricades should be constructed at both ends of the stretch of road under construction. For the guidance of road users at night red lights should be provided at both ends. At night the area should be kept well lighted.

(*xvi*) At the time of actual bitumen spraying, a man with red flag should be posted at each end of the stretch of road under construction to divert the traffic.

4. Safety measures for demolishing the buildings

Demolishing of buildings structure is very hazardous work. Thus the demolition work should be properly planned and executed in different stages. In this way the injuries to workers and accidents can be reduced to a minimum. To ensure safety, cooperation between management, supervisors and workers is extremely important. Before starting the demolition work, the way in which the various parts of the building are supported and to what extent the adjoining structures will be affected by the step by step demolitioning work should be studied carefully. After careful study, the plans for systematic demolition work should be prepared and strictly followed while doing demolitioning work. Demolition operations should not endanger the adjoining structures. The workers should be guided by the foreman at each stage.

4. (*a*) Sequence of operations

The demolition operation should be started in such a way that damage to adjacent buildings and nuisance to public is caused minimum. To avoid accidents all safety requirements should be satisfied.

(*i*) Before starting the demolition work, all glazed doors, windows, and ventilators should be removed.

(*ii*) All exterior wall openings and floor openings, through which a worker may fall down should be provided with barricades and guide rails.

(*iii*) Demolition work should start from top and should be completed in upper most story before starting it in the story below it.

(*iv*) The demolished material should be thrown on ground only after taking all safety measures.

(*v*) Metallic chutes should be used for removing the debris. It is advisable to store the debris inside the building after it has been lowered to the ground.

(*vi*) If the floor below to receive the debris is strong enough to bear its impact then the debris may be dropped directly through holes made in the floor.

(*vii*) Opening in the intermediate floors should not be more than 25% of the area of that floor. These openings should remain covered when not in use and provided with guard rails. Unsafe intermediate floors and supporting walls should be properly shored before starting work.

(*viii*) Stairs and ladders should be kept intact as long as possible and kept safe till demolition work of the story above it is completed.

4. (*b*) Precautions to be taken while demolishing

During demolishing operations following precautions should be observed:

(*i*) Near all sides of the structure to be demolished and approach roads leading to it danger sign boards should be displayed at a distance of 30 m.

(*ii*) At night at important points near the site of demolition red signals should be provided.

(*iii*) If possible a watch man should be engaged to stop entry in dangerous situations.

(*iv*) To safe guard against any damage, the walls of adjoining buildings should be properly strengthened.

(*v*) The demolition work should not be done at night or during heavy rains, and stormy weather etc.

(*vi*) Before starting demolition work electric service lines, gas, water or steam service lines should be closed. The meters installed in the building should be removed or protected.

(*vii*) The passage to be used by workers should be well lighted and free from debris.

(viii) Projected nails in the wooden members should be removed.
(ix) While working at high levels, safety belt should be used by workers.
(x) At the time of demolishing operations, workers must use safety appliances such as goggles, leather gloves, cellolouid lens etc.
(xi) Warning system such as siren should be installed to warn the workers in case of any danger.
(xii) In case of demolishing multi-storeyed buildings, a strong shed should be provided over the side lanes, if it is with in 4.5 m from the building, so that people can use this side walk with out any danger. In other cases strong railing should be provided to keep the people away from the dangerous areas.
(xiii) All the main roads should be kept open to the public. There should be no obstruction to the traffic at any time.

4. (c) Demolition of walls

(i) The walls should be demolished in small heights, layer by layer so that falling debris may not damage or collapse the floor.
(ii) To avoid over loading, the debris should be removed constantly.
(iii) Weaker walls, whose height is more than 15 times of its thickness should be braced laterally.
(iv) Before starting the demolition work of walls in a story, the openings not required for use, should be covered with planks.
(v) In frame structures, steel frames may be left in place during demolishing the masonry work, provided the frame work is sufficiently strong to act as an independent structure.
(vi) At the close of work, walls should be supported against sudden falling.
(vii) The load supporting members should be demolished after the demolishing work in the story above this is completed.
(viii) Foundation walls should be demolished after under pinning the adjoining structures, till then they should be allowed to remain intact.

4. (d) Demolition of floors

(i) For demolishing floors, first of all a 30 cms wide slit is cut for the full length of the slab and 25 cms wide and 5 cms thick planks are placed at 40 cms spacing for workers to do demolishing work.
(ii) Demolished steel structural members should be lowered from the building. They should not be thrown or dropped from the building.
(iii) Beams should be cut only after ensuring all safety precautions to the workers.
(iv) While demolishing external walls of multistoreyed buildings of height more 20 metres, catch platforms of heavy planks should be provided to provide safety to workers as well as to public.
(v) While demolishing a R.C.C. beam, a supporting rope should be put around the beam. Afterwards the concrete is removed from both ends by pneumatic drills and reinforcement exposed.
(vi) The reinforcement should be cut in such a way that the beam could be lowered safety to the floor level.

5. Drilling and blasting

Safety measures while handling explosives. Following precautions should be taken while handling and storing explosives.

5. (a) Transportation

(i) During transportation, explosives and their caps should be kept separately.
(ii) While transporting explosives, the word "Explosives" should be marked or play carded on all sides of the vehicle in bold letters 10 cms in height in colour contrast with the back ground of the vehicle. It should also carry a red flag 60 cms square in size. On the flag word "Explosive" should be written clearly in bold letters.

(*iii*) Detonators or blasting caps should not be transported along with explosives. Metal tools, matches, oils, fire arms, acids, inflammable substances also should not be carried in the vehicle along with explosives.

(*iv*) Vehicles transporting explosives should not be over loaded. In no case explosives be piled in the container higher than the closed sides of the body.

(*v*) Open body vehicles carrying explosives should be covered with tarpaulin.

(*vi*) All vehicles carrying explosives should be inspected carefully for the followings.

(*a*) Brakes and steering mechanism of the vehicle should be in perfect condition.

(*b*) Electric fittings should be well insulated and firmly secured.

(*c*) Body and chassis should be clean and free from accumulation of oil and grease etc.

(*d*) Fuel tank and feed line should be well secured and have no leakage.

(*e*) Two fire extinguishers in working condition should be located near the driver's seat.

(*f*) General condition of the vehicle should be good.

(*vii*) The floor of the vehicle should be tight. Any exposed metal inside the body should be well covered, so that explosive may not come in its contact.

(*viii*) No trailer should be attached to the vehicle carrying explosives.

(*ix*) Unauthorised persons or passengers should not be allowed to ride in the vehicle carrying explosives.

(*x*) Packages of explosives should not be thrown while loading or unloading. Explosive packages should be handled and lifted carefully.

(*xi*) Before loading or un loading explosives the engine of the vehicle should be stopped.

5. (*b*) Precautions while handling explosives

(*i*) The packages containing explosives should be lifted or lowered carefully. They should never be dropped or slide from one level to another level.

(*ii*) Packages containing explosives should neither be opened in side a magazine nor with in 20 m of the magazine.

(*iii*) Non metallic or wooden tools should be used for opening or packing the boxes containing explosives.

(*iv*) Explosives and detonators should be placed in separate insulted and closed carriers.

(*v*) No unauthorised person should be allowed to ride the vehicle.

5. (*c*) Precautions while storing the explosives

(*i*) Explosives should be stored in dry, well ventilated, fire resistant and bullet proof building.

(*ii*) Primers or blasting caps should be stored separately.

(*iii*) Explosives, fuse lighters etc. should not be stored in damp places or near oil or near any source of heat.

(*iv*) No grass or leaves should be stored with in 8 m of a magazine.

(*v*) Smoking or lighting any flame should not be allowed near a magazine. Warning notice should be displayed.

5. (*d*) Safety measures while drilling and loading explosives

(*i*) Before planning the drilling operations, the nature of the strata should be examined carefully to avoid sliding after blasting.

(*ii*) Drilling should not be done where undetonated explosives are suspected.

(*iii*) Before loading the explosive in the hole, it should be ensured that the hole is bored in full length and is free from dust etc.

(*iv*) Excess explosive should not be left near the site while loading the hole.

(*v*) Before loading a hole it should be ensured that the hole is cool and has no burning material in it.

(vi) While inserting the explosive into a bore hole no force should be applied.
(vii) Force also should not be applied while inserting the blasting cap into the explosive.
(viii) While placing the explosive in the hole, tamping should be done with wooden tools. In no case metal tamping rod should be used for this purpose.
(ix) The explosive should be confined to the bore hole with stemming material as earth, clay, or sand etc.
(x) While tamping it should be ensured that fuse wire is not damaged.
(xi) Detonating fuse should be connected to the blasting cap or electric blasting cap according to the instructions issued by the manufacturers.

5. (e) Safety measures while using the explosives

(i) At the place where explosives are to be used smoking or lighting fire should not be allowed.
(ii) After taking out the required quantity of explosive from the container it should be covered properly.
(iii) Explosives should not be carried in the pockets of clothings.
(iv) No body should be allowed to remove or investigate the contents of a blasting cap.
(v) No unauthorised person should be allowed to go near the place of use of explosive.
(vi) Explosives should not be handled in electrical stores.
(vii) Deterioted explosives should not be used.
(viii) Hard set explosives should not be softened by heating over the fire or rolling it on the ground.

5. (f) Safety measures adopted while electrical short firing

(i) During stormy weather uncoiling of wires and opening out of bare leading wires of blasting caps should not be allowed.
(ii) Firing circuits should be fully insulted from pipes, rails or ground.
(iii) Electric line wires should not be kept near the blasting caps or other explosives except at the time of firing the blast.
(iv) Electric cap wires or leading wires should be kept short circuited till ready to fire.
(v) In case blasting is to be done from power circuit, then the voltage should not be more than 220 volts.
(vi) Blasting operations near the over head power lines, communication lines, or other structures should be done after obtaining the prior permission from the competent authority and after ensuring all necessary precautions.
(vii) For the size of wires, fuses, circuits etc. the instructions issued by the manufacturers should be followed.
(viii) For firing of a circuit of electric, blasting cap with less current than specified value by manufacturers should not be allowed.
(ix) All holes loaded on a shift should be fired on the same shift.

5. (g) Safety measures for short firing with safety fuse

(i) To safe guard against the damage of fuse cover, it should be handled carefully.
(ii) The length of fuse wire should not be less than 1.2 m.
(iii) The time of burning of the full length of the fuse should not be less than 2.0 minutes. The rate of burning of fuse should be such that the person igniting it reaches the place of safety before the blast.
(iv) The fuse should be ignited with a fuse lighter of proper design.
(v) Before igniting the fuse, sufficient stemming should be placed over the explosive.
(vi) At the time of lighting the fuse, spare explosive should not be held in hand.
(vii) Excessive quantities of explosives should not be taken under ground.

5. (*h*) Safety measures to be adopted before and after firing

(*i*) Before firing, sufficient warning time should be given to persons working at the site to go to safe place or away from the danger zone.

(*ii*) Flag men should be posted on all approaches to keep the vehicles and public at least 400 m away from the danger zone.

(*iii*) No tool or other articles should be placed on the rock to be blasted.

(*iv*) Blasting should be done as per schedule, during the fixed hours of the day. Wide publicity should be given of the programme. Daily blasting hours should be displayed on the notice boards on all roads leading to the blasting site. At the time of actual firing traffic should be stopped 400 m away with the help of barriers. At the beginning and at the end of firing loud sirens should be sounded.

(*v*) The person who fires the shot should not return to the blasting site untill at least 5 minute have passed from the time of lighting the fuse. In case of electric shot firing the shot holes should be examined after firing and in case of misfiring no one should be allowed to come near the blasting site at least for 3 minutes and in case of firing with safety fuse, the time for preventing entry of any one to blasting site is 30 minutes.

(*vi*) In case of misfire, the steming should be removed by the use of water jet or air jet, till the hole has been opened to with in 60 cms of the cartridge. The water is then pumped out and fresh new charge placed and detonated.

(*vii*) No explosive should be abandoned or thrown away. It should be disposed off after consulting the appropriate authority.

(*viii*) Material used in packing of the explosive should not be stored at a place where it could prove dangerous to the human life. Papers used for packing explosives should be destroyed. They should not be used any where else.

18.9. ROLE OF VARIOUS PARTIES IN SAFETY MANAGEMENT

1. Designer. At the planning stage, the architect, engineers and designers should give due consideration to the safety of the workers. They should take into account the safety problems associated with the subsequent maintenance of structures. The designer should avoid anything in design which would require the use of dangerous structural procedures and hazards. Special care should be taken in case of tall buildings for cleaning the windows on the outside.

2. Employer. The employer should provide and maintain plant and equipment well and organise the work in such a manner that workers are protected against the risks of accidents. The employer should also ensure proper supervision to workers to perform their work under the best conditions of safety. Workers should be supervised by a person who knows the safety requirements and is competent enough to handle them. Workers should be given proper instructions about safety requirements.

3. Workers. All workers should do everything with in their power to provide safety to themselves and to coworkers also. Before starting the day's work they should inspect the place of work and equipment they have to use and any defect observed by them should be reported to the supervisor or any other competent authority. They should use all safeguards and safety devices etc. Precautions to be observed have already been discussed.

18.10. APPROACH TO IMPROVE SAFETY IN CONSTRUCTION WORK

Many rules and recommendations have been laid on how to improve safety in the construction work based on the research carriedout by several organisations and societies. Recognising the importance of safety performance, the approach to the safety problems can be made as follows:

(*a*) Organisational approach. The management may setup a safety department to look after the safety aspects of workers and job site representatives. It should also record and analyse the safety and other accident prevention programmes. Safety representative on each site should not be hired by

the project management as it may compromise in safety issues later.

(b) **Safety committee.** A safety committee may be set up to guide the operation of safety programme. In this committee people from all levels of workers and management should be included so that opinion on safety measures from all sections of the organisation may be gathered.

(c) **Development of a safety system.** A system should be developed to process the safety suggestions from workers and people who carry out the daily construction process as they are in best position to detect any accident.

(d) **Incentives.** For field management and supervisors incentives may be declared on the basis of safety record as well as productivity and cost.

2. **Physical approach.** Under this head, to improve the safety performance following guide lines may be used.

(a) New workers should be taught safety features. It has been observed that new workers suffer more accidents than experienced workers. Hence they should be given proper guidance in safety measures.

(b) In hazardous jobs, the use of safety devices should be made compulsory for the workers as use of helmet, safety belt, safety glasses, Goggles, gloves and hearing device etc.

(c) Periodic checking of equipment and tools should be done to ensure that they are well maintained.

(d) Periodic safety meetings may be held to provide safety education to the workers.

3. **Behavioural approach.** Studies carried out by several agencies have revealed that about 80% of all accident take place due to the unsafe acts of workers and only about 10% accidents occur due to failure of equipment or faulty procedures etc. Hence works acts are the most important for improving safety performance. In this regard following guide lines may be useful.

(a) The management during their meetings should give same stress to the safety as to the schedule of time and cost. This will make the lower staff understand that safety is as important as schedule and cost. Thus the importance of safety will not be ignored.

(b) Unnecessary pressure on foreman should not be put to meet the schedule or estimated cost. Usually pressures encourage the foreman to choose unacceptable methods that often lead to higher possibility of accidents.

(c) Craft foremen are in better position to detect the abnormal behaviour of workers as they have daily contact with them.

(d) There should be sweet and cordial relationship between the management and employees.

8.11. SAFETY CAMPAIGN

For each and every construction industry, safety campaign is very essential. It should be made compulsory to be conducted by law. It is the responsibility of the management to launch the campaign and contribute the continuing support to keep it operating effectively. For carrying out safety campaign following steps may be adopted.

(a) An capable and experienced person should be made incharge of the safety campaign. He should be fully supported by the management.

(b) The safety director must ensure that all new workers have been educated to observe safety measures and he should have the power to get safety measures adopted by the workers.

(c) Committees should be formed consisting representatives of management, supervisors, and workers to go round each job frequently and find out deficiencies and causes for the likelyhood of accidents and suggest remedial measures. They should be encouraged to suggest new measures to promote safety.

(d) Safety rules to be observed in each section, should be written on notice boards in the language which may be easily understood by workers.

(e) DO's and DONT's must be written on separate notice boards. The notice boards should be placed at such places, where the workers could see them daily easily.

(*f*) Safety material should be brought out by the management periodically and distributed freely to the workers.

(*g*) The accident record of each concerned department should be displayed. Efforts should be made to reduce the number of accidents by adopting suitable safety measures.

(*h*) Safety contests should be held from time to time to enlighten the workers about the bad effects of accidents. Awards should be given to those supervisors, who produce best safety records. The names of prize winners must be publicised.

(*i*) Suitable safety quotations should be displayed written in bold letters on sign boards. Following quotations may be displayed.

1. To save time at the cost of life is a bad bargain.
2. Accidents do not happen, they are caused.
3. Where caution end, accidents begin.
4. Machines are good servant only if handled carefully.
5. Safety first and speed after wards.
6. Safe driving is a pleasure.
7. Make safety a habit.
8. Safety first and luck after wards.
9. If married divorce speed.
10. Safety saves.

(*j*) Safety weeks must be observed. Workers and public should be educated during this week about safety measures.

18.12. MEASURING OF SAFETY

Some terms are defined below which indicate the measure of injury:

1. **Injury frequency rate.** It is the number of disabling injures per one lakh man hours worked. It denotes how frequently an accident occurred. It does not take into account the time lost due to injury. It is expressed as

$$\text{Injury frequency rate} = \frac{\text{no. of disabling injuries} \times 10^5}{\text{total no. of man hours worked}}$$

2. **Injury severity rate.** It is the number of days lost per 1000 man hours worked. It is expressed as

$$\text{Injury severity rate} = \frac{\text{no. of days lost} \times 10^3}{\text{no. of man hours worked}}$$

3. **Injury index.** It is expressed as

$$\text{Injury index} = \frac{\text{injury frequency rate} \times \text{injury severity rate}}{1000}$$

18.13. PREVENTION OF FIRES AT CONSTRUCTION SITES

Construction activity provides many opportunities to the spread of fire at the construction site as many activities are carried out simultaneously which may cause fire and there are very limited means of controlling fire at the site of work. In case of a fire hazard in a construction project, it not only damages equipments and causes injuries to workers, but also delays the completion of the project resulting in escalation of cost. There is a general conception that fire hazard at construction projects is negligible, hence no pre planning is made to meet the fire hazards.

Now a days due to the increase in the use of plastic materials as building materials, the chances of spread of fire have increased very much. Secondly materials in large quantities are stored in open at project site which also add to the chances of fire hazards.

The climatic conditions, make shift arrangements for timber form work and scaffolding, use of temporary electric wiring and connections, lack of availability of resources to control fire hazard etc.

greater fire risk. Actually alteration and rehabilitation measures to a building present greater risk of fire hazard than construction as it is carried out with parts of building still in use.

From the study of fire hazards at construction site, it is observed that frequent causes of fire are due to electrical short circuits, un controlled welding etc. Poor house keeping and unsafe storage of materials also are responsible for fire hazards. It has been found that main reasons of fires are as below:

(a) Due to portable heating equipment	25%
(b) Due to welding and cutting operations	20%
(c) Smoking and matches etc.	15%
	60%

Hence proper planning for fire prevention should be done.

MODULE 6

Construction procedures: different methods of construction – types of contract – Tenders – prequalification procedure - earnest money deposit – contract document – General and important conditions of contract - measurement and measurement book - Inspection and quality control - need, principles and stages, Basics of Total Quality Management

Different methods of construction

Three Basic Sectors of Construction :

- Buildings: Building construction is usually further divided into residential and non-residential (commercial/institutional). Provides places where people live, such as houses, apartments and the office, factory buildings etc.
- Commercial/Industrial Construction: Industrial construction includes refineries, process chemical, power generation, mills and manufacturing plants. It also includes office structures, shopping malls, and factories, as well as churches and other houses of worship.
- Civil Construction/ infrastructure: Infrastructure is often called heavy civil or heavy engineering that includes large public works, dams, bridges, highways, railways, water or wastewater and utility distribution.

1. **Traditional Construction:**

- The term 'traditional build' is most often used to describe a structure where the internal load bearing leaf of the walling is of masonry construction.
- Although Modern Methods of Construction are taking building practices into the future, traditional brick and block methods still remain one of the most widely used build types.

2. **Lightweight Aerated (Aircrete) Blocks:**

- Lightweight Aerated (Aircrete) Blocks are suitable for foundations, internal and external leaves of cavity walls, solid walls, internal walls and party walls.
- They provide a far greater thermal efficiency but usually require the application of an external wall insulation system to achieve current building regulations.

3. **Thin joint blockwork :**

- Thin joint blockwork (thin joint masonry) is a fast, clean, accurate system for construction using autoclaved aerated concrete blocks of close dimensional tolerance with 2mm-3mm mortar joints.
- Thin layer mortar is a pre-mixed cement-based product that only requires the addition of water to make an easily-applied mortar.
- It differs from general use mortar in that it sets more rapidly, thus giving early stability to the construction.
- It provides an alternative to traditional sand/cement mortar and allows the depth of the mortar to be reduced from at least 10mm to 3mm or less.

4. **Precast Flat Panel System:**

- Floor and wall units are produced off-site in a factory and erected on-site to form robust structures, ideal for all repetitive cellular projects.
- Panels can include services, windows, doors and finishes.
- Building envelope panels with factory fitted insulation and decorative cladding can also be used as load-bearing elements.
- This offers factory quality and accuracy, together with speed of erection on-site.

5. 3D Volumetric Construction:

- 3D Volumetric construction (also known as modular construction) involves the production of three-dimensional units in controlled factory conditions prior to transportation to site.
- Modules can be brought to site in a variety of forms, ranging from a basic structure to one with all internal and external finishes and services installed, all ready for assembly.

6. **Flat Slabs:**

- Flat slabs are built quickly due to modern formwork being simplified and minimised.
- Rapid turnaround is achieved using a combination of early striking and panelised formwork systems.

7. **Twin Wall Technology:**

- The prefabricated panels comprise two slabs separated and connected by cast-in lattice girders.
- The units are placed, temporarily propped, and then joined by reinforcing and concreting the cavity on site.
- Twin wall is usually employed in association with precast flooring systems.

8. **Precast Foundations:**

- Precast concrete systems can be used to rapidly construct foundations.
- The elements are usually to a bespoke design and cast in a factory environment, giving assured quality for the finished product.
- The foundations are often supported by concrete piles and connected together.

CONTRACT

A construction contract is an agreement between an owner (many times a government department such as PWD, etc.) and a contractor (an individual or a contractor organization) to get a construction work done according to some terms and conditions. The agreement binds both the parties by the terms and conditions of the contract. The contract agreement generally stipulates the following particulars in it.

- Quantities of works
- Approved rates for different types of works and materials
- Specifications for various types of jobs in the construction project
- Time limit for the completion of the project and
- Other terms and conditions for the work
- Penalty clauses to be applied if the contractor does not do the work satisfactorily.

In other words, contract is an undertaking by a person or firm to do a work under certain terms and conditions. The person or the firm, as mentioned above, is generally called as a contractor

TYPES OF CONTRACTS

There are various types of contracts to suit various conditions. Sometimes particular types of contracts are considered to be suitable for particular types of jobs. We must have the knowledge of various types of contracts and their salient features. Some types of contracts are being explained below.

1. Lump Sum Contract

In this type of contract a fixed amount of money is charged by the contractor to complete a work satisfactorily under certain terms & conditions, agreed upon before the start of work.

Detailed specifications of the work are given to the contractor in the tender document. All the plans and drawings also are made available. The contractor has to work out the bills of quantities from these drawings and has to suggest a fixed sum of money for the completion of the work. After the completion of the work, the completed work is checked from the drawings but no detailed measurement of the quantities of materials is made.

2. Lump Sum and Schedule Contract

This is a form of the lump sum contract where the conditions applicable to the lump sum contract generally apply. In this case a schedule document is provided to the contractor in which rates for different types of work materials are given. In such a contract, the contractor is paid the lump sum amount of money as also extra amount if some additional amount of work is done by the contractor. This extra amount of money is calculated as per schedule of rates for the extra work done by the contractor. This gives some flexibility to the contract as any additional work, which was not included at the start of work, also may be got completed form the contractor.

3. Schedule Rate or Item Rate Contract

In this type of contract the contractor does the work on an item rate basis. The quantities of various items of work are calculated and payment is made on the basis of quantity. The contract agreement includes quantities, rates and other associated information such as detailed specifications etc. The payment to the contractor is made after detailed measurements of different items of work actually done by the contractor.

Depending on the conditions, the item rate contract may include rates which may be somewhat lower or higher than those given in the schedule of rates. This may be possible if some special conditions at the site justify the higher percentage of rates. For example, higher rates may have to be given to contractors to attract them for taking up construction jobs in a difficult terrain, such as in a hilly area.

4. Labour Contract

In this type of contract, the contractor undertakes contract for providing labour at the site. All materials are to be supplied by the department and the contractor is paid for the labour portion of the cost. The quantities of various items of work are to be measured and the required number of workers is calculated. The contractor is paid the amount for the required number of workers.

Whether the contractor is entitled to use his own tools and plants and other equipment is included in the agreement. This system of work is not generally used in government departments but in private construction it is frequently used. There the owner provides the materials and arranges equipment and pays for the labour arranged by the contractor.

5. Material supply contract

In this form of contract, a contractor has to offer his rates for supply of the materials, inclusive of all local taxes, carriage and delivery charges to the specified stores within the time limit prescribed in the tender

6. Percentage rate contract

When the lowest rate and comparative position among the contractors are already specified prior to the opening of the tender, then the percentage rate contract is used. Percentage contract is a type of contract where there is no possibility of unbalanced tender.

7. Cost Plus type Contracts

- **Cost Plus Percentage Contract**

In this type of contract, the contractor is paid some additional amount of money for the timely and satisfactory completion of the construction project above what is his due. This encourages the contractor to maintain the quality of work as well as to complete the construction work in time. As delay in the completion of project may increase the project costs, it may limit the delays and ultimately save some money of the department.

It may so happen that the contractor may try to complete the project in a short time without caring for the quality of work due to the additional amount of money for the timely or early completion of work. It is very important that the quality of construction is maintained by regular and proper supervision.

It is also important to include a penalty clause in the contract agreement so that appropriate action may be taken against a contractor who does not do a good work. A penalty or compensation may be imposed on the contractor for delays in the construction period. The maximum limit of penalty may be around 10% of the total contract amount.

- **Cost plus fixed fee contract**

In cost plus fixed fee, the owner pays the contractor an agreed amount over and above the documented cost of work.

This is a negotiated type of contract where actual and direct costs are paid for and additional fee is given for overhead and profit is normally negotiated among parties. The owner is in more control of the project; however, the risks are transferred to the owner.

A cost plus contract states that a client agrees to reimburse a construction company for building expenses such as labour, materials, and other costs, plus additional payment usually stated as a percentage of the contract's full price.

This type of construction contract is an alternative to lump sum agreements. It allows flexibility and transparency for the homeowner, and reduces the risk for a contractor since a Cost Plus construction contract guarantees them a profit.

- **Cost plus sliding or fluctuating fee scale contract**

The contractor gets actual cost of construction plus an amount of fee (% of construction cost) inversely variable according to the increase or decrease of the estimated cost agreed first by both the parties. The amount of fee is determined by reference to some sliding scale. Thus, higher the actual cost, the lower is the value of the fee the contractor receives and vice versa. From the owner's point of view, this is the best of cost plus type contracts. It's developed form is target contract.

8. Build Operate Transfer (BOT) Contract

This is a form of contract in which the contractor is to build a facility. The contractor operates the facility for some time to recover the costs. After the costs of the construction work with profits are recovered by the contractor, the facility is transferred to the owning department. Any maintenance costs during the operation of the facility are also recovered by the contractor.

For example, you must have seen toll taxes being collected at the site of a newly constructed bridge by a contractor authorized by a department. The contractor collects money from vehicle owners crossing some river using the bridge. This way the vehicle owners pay money for using the facility and the contractor is able to compensate himself for the costs incurred for the construction of the facility.

The BOT projects are usually long-term in nature as a long time is required to recover the costs incurred in the construction and maintenance of the facility. After the recovery of the full cost by the contractor, these types of projects are normally transferred to the government.

In BOT type of projects, the lenders (parties or organizations financing the construction of the project) consider the future earnings of the project as the prime factor for lending the money. Their credit is based on the project earnings, not on the creditworthiness of the contractor. The lenders usually take the security of the project assets as a guarantee against the financed money.

9. Target Cost Construction Contract

Target cost contract has mutual features of the lump sum and cost plus contracts. The contractor is paid based on the actual costs plus a certain fee either fixed or percentage of total cost in case of the cost of the project doesn't exceed certain target cost specified by the owner.

There is risk carried by the contractor in case of increase in cost of construction project. The contractor is also rewarded a percentage of any savings between target and actual cost.

10. Negotiated contract

When the contract is awarded without calling tenders on the basis of negotiation only, it is called negotiated contract. It may be any form discussed above

11. Subcontract agreement

A subcontractor agreement is a contract primarily between a builder or a principal contractor and subcontractor. It outlines the perimeters of specialist work to be done for the construction project

MODULE VI

Construction procedures – different methods of construction – types of contract – Tenders – prequalification procedure – EMD – Contract document – General & important condition of contract – Measurement & measurement book – Inspection and quality control – need – principles, stages – Basics of TQM

TENDERS

Whenever a government agency or a firm wants certain works to be done, services to be rendered or any purchases to be made, they float tenders in order to get the work done at competative prices. The person who quotes the lowest price agreeing to the terms and conditions imposed on him, will have to sign an agreement stating that he will perform the said work as per requirement of owner/client.

Calling of tenders and entrusting the works based on these tenders enables the owner/client to get work done at least cost. Also, the selection of contractors can be made based on his experience and capacity By this method of awarding works, personal interests, prejudices, preferences, partiality etc can be avoided.

Tender Notice

The tenders are to be given publicity in leading dailies by way of advertisement & time duration of about a month may be given for the submission of tenders. However the tender notice should convey the following informations :-

i) Name of department calling for tenders.
ii) Name of work and location
iii) Designation of the officer inviting tenders
iv) Last date and time of receipt of tenders
v) Period of availability of tender forms
vi) Cost of tender documents
vii) Time of completion and type of contract
viii) Earnest money deposit to be paid
ix) Date, time and place of opening tenders
x) Designation of the officer opening the tenders

The tenders are opened by the concerned officer at the place and time mentioned in the tender. The contractors or their representatives are to be present during the opening of tenders.

There may be cases when the works are to be completed quickly or no contractor prefers to offer his acceptance when a tender is floated. In such a case, a notice with short duration is again published by the client. Such tender is called short tender notice. But the terms and conditions remains the same as that of ordinary tender notice. Sometimes, for small jobs, quotations are invited from contractors and the work is awarded based on the quoted amount and experience of the contractor.

Types of Tenders

1) Open tenders
2) Limited tenders
3) Single tender

① Open Tender

This type of tender invites the contractors to bid by open advertisement in the Indian Trade Journals and other newspapers

② Limited Tender

In this type, only a selected number of contractors are invited to quote their rates for the supply of articles.

③ Single Tender

In this, invitation to only one firm to tender a service by quoting their rates. If the client finds that the quoted rates are too high, then there may be negotiations prior to the agreement of the contract.

④ Rate Contract

This contract is normally used for supply of store items. It specifies the supply at a fixed rate during the period of contract. The quantities are not mentioned in this type of contractor and the contractor is bound to accept any order which would be placed before him.

Issuing of tender calls

Not going for publications in papers/media. Published only in notice board of organisation with the permission of higher authorities.

① Quotations

② Negotiated Quotations.

(1) Quotations

* Award of contract by obtaining competative quotations in case of emergency
* Normally 3 days notice in notice board of section, subdivision and division
* Normally at the estimated rate
* No tender excess will be given but it can raise upto estimate based WPI (wholesale price index) or CPI (Consumer price index)
  [WPI → published by Central Ministry of Commerce
  CPI → published by Ministry of Statistics & program implementation]
* EMD should be remitted.
* It is subjected to sanction by immediate superior officer.

(2) Negotiated Quotations.

* It is admitted in such a situation that there is no time for arrangement of work or if there is no response for quotation invited.
* Maximum rate is limited to estimate rate based on local market rate fixed by Executive Engg.
* Approval by immediate superior officer is required.

E-Tendering

Procen of inviting, accepting and processing tends and communicating through medium of internet is from advertisement to placing of contract.

Tender Documents

The tenders to be called should necessarily meet the requirements of the construction. Normally, a tender document consists of the following parts

1) General conditions of tender.
2) Schedule of items of work with clear specifications.
3) Special Conditions.

Besides the above details, the following particulars must be furnished in the tender documents

a) Location of work
b) Division in which the location is situated
c) Approximate quantity of work under each item.
d) Nearest rail/road link.
e) Details of nearby availability of materials like brick, jelly.
f) Hire charges that will be charged by the client for lorries, tools and plants when issued from client's store.
h) Location of water supply point.
i) Time for completion and the progress to be made at intervals of time.
j) Condition regarding employment of technical personnel.
k) Details of specific material, process and methods to be adopted in work.
l) Weather conditions in the area and period of operation.
m) Amount of EMD and the form in which it has to be paid.
n) Insistence on license tax and sales tax clearance certificates.
o) Power of rejecting tenders without assigning reasons.
p) Penalty conditions for slow progress and delays in the completion of work.
q) Designation of the arbitration authority in case of disputes.

Earnest Money Deposit and Security Deposit (SD)

(EMD)

While submitting the tender, the contractor will have to deposit an amount which is about 2% of the estimated contract value of the project. This amount is called EMD - Earnest money deposit. This amount is collected in order to avoid the contractor from refusing to accept the contract, once he is awarded the work. But the EMD of unsuccessful contractors will be refunded to them. The EMD is also collected to avoid unnecessary competition by avoiding the contractors who may not have sound financial status. Also, if the lowest quoted contractor refuses to take up the work, his EMD will be forfeited by the client. This amount will to some extent compensate for the loss suffered by the client, since he has to offer the job to the second lowest tenderer.

Once the tender of a contractor is accepted by the client, the contractor is to deposit about 10% of the tender amount with the client. This amount is inclusive of the EMD already paid by him. This amount is called SD - Security Deposit. This deposit serves as guarantee that the contractor performs the works as per specification and maintains satisfactory progress. The SD is refunded to the contractor generally after the maintenance period of 6 or 12 months from the date of handover of the works to the client. During this period, if there is any defect in the work, it will be rectified and the cost of rectification will be deducted from the SD.

Scrutiny And Acceptance of Tender.

Once the tenders are opened, they are to be scrutinized by the competent authority of the client. Comparative statements are prepared to compare the rate of various tenders in respect of each item against the estimated rates. The savings for each tender is known. Then, it is to be seen whether the contractor has agreed to all the conditions in the tender or he has stipulated any conditions.

Based on the comparative statement as prepared above, the lowest tender is usually accepted. But, if the lowest tender has not performed satisfactorily in previous jobs or if there is any doubt about the capacity of the contractor, then the second lowest tenderer may be asked to take up the job. If the contractor doesnot wish to perform the job, he has to withdraw his tender prior to the acceptance by the client. If the tenderer withdraws the tender after the work is awarded to him, then his EMD will be forfeited by the client.

Contract Agreement.

Contract agreement is a legal document which binds the contractor and the client to follow the rules and regulations given in the document until the work entrusted to the contractor is completed/signed by both parties.

The contract agreement normally contains :-

1) Title page with name of work and contract agreement number.
2) Index page giving the contents of the agreement with page references.

3) Tender notice with description of work, locations, items, period of completion etc.
4) Bill of quantities and total cost of work duly calculated
5) Schedule of issue of materials / rates.
6) General specifications giving the clauses and type of work.
7) Detailed specification for each item of work and materials
8) Lead particulars for bricks, Sand, jelly etc.
9) Complete drawings with plan, elevation, site plan and other relevant detailed drawings.
10) Conditions of contract giving rate of labour, materials, tools and plants, progress rate etc.
11) Special conditions regarding nature of work, taxes, royalties, labour amenities etc

Steps in Tendering / Stages

1) Issue of notice.
Normally 7 - 10 days publishing in newspaper and also in website
2) For major works.
Pre bidding meetings will be conducted.
3) Submission
4) Register the tenders / opening tenders
5) Tabulation & Scrutiny.
6) Negotiation.
Negotiation is done with high bids or no response.
7) Approval of Tender excess, if any.

8) Award of work
9) Agreement

Prerequisites for Bidding of work

* Administrative sanction and Technical sanction is a prerequisite for bidding of work
* 100% tenderence free land and 60% land (in case of road) should be available with prior permission from government.
* Verify changes in rate and amount
* Check time lag between sanction and tendering
* Check for modification required in recent estimate and get sanction from original authority.
  If expenditure has been made, revised estimate has to be made.
* Follow tender procedure.

Contract / Tender Documents

The various terms and conditions of contract which are to be formulated while inviting tender for a Civil Engineering work are:-

Title Page → Name of work
Name of owner.

1) Notice Inviting Tender / Invitation for bidders

Notice inviting tender should contain.

- Name of work
- Name of employer / owner
- Cost of work
- Date of tender (tender due date).
- Packing and Submission.

- Opening of tender date
- Conditions for acceptance of tender
  (Normally conditional tenders ll not be accepted
  Tender should be unconditional).
- Award (satisfaction requirement)
  Based on qualification and lowest bid

Notice Inviting Tender

Name of work	Estimated Cost	Price of tender forms & schedule	Earnest Money	Time of Completion	Accepting authority

2) Instruction to Bidders

- Name of work
- Purpose of work
- Eligibility/Qualification Criteria
- Instruction to inspect the site (details of works)
- Instruction regarding how to quote (contract type).
- Principle aspects (name of work, cost of tender form, EMD, opening time etc).
- Probable Amount of contract (PAC) (Time of receipt, date & time of examination

3) Conditions of Contract (General Conditions).

- Definitions
  * Who is the client
  * Definition of engineer
  * Definition of contract – conditions of contract
    specification of bills
    rates etc
  * Contract Price – sum stated in the letters of acceptance

* Definitions regarding work – temporary & permanent work.

– Experience.

* Statement regarding work, site, acceptance authority, meaning of tendered value, labour position, material position, tools etc.
* Tender documents
* Quality Control
* MT lab
* Narrative Cost
* All matters related to work.

– Specifications.

4) Special conditions of Contract

* Conditions shall be approved by the next higher authority.
* More Specific conditions.
* Specially regard to time of contract, penalty clauses, payment conditions, disputes etc.

5) General Informations of the project.

* Site location.
* Scope.
* Detailed component wise scope ie civil, mechanical, electrical etc.

6) General Technical Specification

* Standards for components or class of work.
  - Specifications regarding to ordinary work, medium work etc.

* IS for concrete, steel, aggregate, tile, formwork etc.
* Standards for laying concrete, workmanship.

7) Special Technical Specification

Special specific to scope of work

8) Schedule of Quantity

Bill of quantities / Tender schedule.

9) Drawings, if any

10) Forms & other relevant informations.

- Mainly for qualification in case of post qualification works.

11) List of mandatory tests.

12) Preliminary Agreement.

Qualification Criteria

For major works above technical sanction (TS) power of SE, the contract should have some qualification technically and financially.

Major Works → Post Qualification
Major Works → Prequalification (>5 crore)

1) Prequalification.

In this method initially a notice is published to invite intending bidders to express their interest in bidding for a particular work. They are asked to furnish information

on several points on the basis of which screening is done. Tender forms are issued only to those contractors who pass the selection criteria. In this system, they number and identity of tenders who can bid gets frozen at the outset. Thereafter the bids of all the bidders have to be opened and the work is awarded straight way to the lowest responsive bidder since every bidder is already screened. Sometimes this system is not favoured because it consumes a lot of time because of two notice periods, one for prequalification and then again for the bid proper and also each bidder know who other bidders are. It is also seen sometimes that an unworthy entity finds place in the prequalification list.

2) Post Qualification

In this system, the qualification criteria are set and put in the bid documents. The bidders are asked to supply detailed information on these criteria. The bids will be opened and the bid of the lowest quoted bidder will be evaluated on the basis of such information. The employer will evaluate and compare only bids determined to be substantially responsive. A substantially responsive bid is one which forms to all terms and conditions and specification of the bidding documents. The employer will award the contract to the bidder whose bid has been substantially responsive to the bidding document and who has offered lowest evaluated bid price.

In this system, no bidder knows in advance as to who the other bidders are since they can put in a bid at the last minute. However, downside as that every bidder has to incur expenditure and effort to prepare a detailed bid whether he is going to qualify or not.

Qualification criteria for finance status :-

* Bid Capacity
* Financial Standing
* Net worth
* Local standing
* Annual Turnover.

Qualification criteria for technical status :-

* From technical side, past experience for last 3-5 is checked
* For single works, it can be 50% of size of work and sometimes only 25% of size of work.
* For single works, the nature of work and cost of work is also checked as criteria for qualification.

Measurements

Measurements of a building occupies a very important place in the planning and execution of any civil engineering works from time of first estimate to the final completion and settlement of payment for the project. The work is divided into sub heads for keeping accounts of money and materials accurately. Accuracy is a must in measurement and should be kept as under.

a) Dimensions shall be measured to the nearest 0.01 metre
b) Area shall be worked out to the nearest 0.01 square metre
c) Cubic components shall be worked out to the nearest 0.01 cubic metre.

Measurement Book (MB)

Measurement book is very important in case of PWD and hence it should be maintained carefully. The measurements of all the works and supplies are recorded in the MB Form 23. It is in the form of a notebook of size 15cm x 10cm and contains instructions how to write up the columns for particulars. It also contains details of actual measurements in terms of length, breadth and depth and the contents or area. All pages of every measurement books are machine-numbered and all measurement books are numbered serially. A register is maintained in the divisional office showing the serial number of each MB, the names of the sub division or officer to whom issued, the date of issue, the date of return and remarks. A similar register is maintained at the sub divisional office showing names of the officers to whom issued, Date of Issue, Date of return etc. Each MB has some leaves for index, for review by the divisional Accountant and for review by the EE (Ex. Engg)

Loss of MB:

Loss of MB is a very serious matter and has to be reported to the highest authorities immediatly. It is an initial document of accounts and hence a serious matter. After getting intimation on loss of MB, the superintending Engineer (SE) investigates the detail the cause of loss. Suitable action is taken if anybody is found responsible. If the loss of MB could not be

traced at the lapse of 6 months, an application for sanction of write-off together with full report and explanation should be submitted to the CE (Chief Engg.) who is authorized to sanction the write off.

Checking of measurements :-

In order to exercise proper control and check, certain percentage of measurements recorded by subordinate officers are required to be checked by Asst. Engg. (AE) and Executive Engineer (EE).

Percentage of checking is as follows :-

a) In case work has been done by the departmental labour, AE will check 15% of measurements and EE 7.5 to 10% of measurements of each sub division.

b) In case of works done by the contractor on item rate basis AE is supposed to check 25% of measurements and EE 5 to 50% of measurements of each sub division.

The checking of measurements should be done in the presence of person who recorded the measurements.

On Checking :,

→ If the difference is not more than 1% in the case of original work, 5% in the case of repair work and 10% in the case of earthwork, the entries shall be corrected and initiated.

→ If the difference exceeds the above mentioned limits the measurements shall be cancelled or order should be given for measurements again.

Standard Measurement Book (SMB)

SMB is mainly used for periodical repairs and maintenance works, which are to be carried out at fixed intervals of time. For small works, it may be single MB but in case of large works, it consists of a set of MBs. Single MB or a set of MBs where the detailed measurements of certain items of works of a building is recorded correctly in it after the completion of construction and whose accuracy is certified by an officer of the rank not less than AE is known as SMB. Any alteration in structure is entered in the SMB. SMB is checked every 5 years and this checking is termed as Quin Quennial Checking.

Measurement Book Kerala PWD

Name of Work: Date of measurement

Name of contractor Agreement No.

Reference to estimate		Particulars	1	2	3	4	5	6		7		8			9		Remarks
Sub head	Item no		Measurement up-to-date					Rate		Total value to date		Deduct previous measurement			Since last measurement		
			No	L	B	D	Contents or area	Rs	p	Rs	p	book	Page	quantity	Quantity col (5-8)	Value at rate in col. 6	
																Rs	p

INSPECTION AND QUALITY CONTROL

Introduction-Need for Inspection and Quality Control-Principles of Inspection-Major Items in Construction Job Requiring Quality-Stages of Inspection and Quality Control

INTRODUCTION

Inspection is needed for maintaining quality in a construction project. Different aspects of quality are to be considered. Different types of inspection and quality control procedures may apply to different materials. An engineer should be conversant with all these procedures.

NEED FOR INSPECTION AND QUALITY CONTROL

Every operation is connected with the quality of the product. In the case of construction the quality of construction is to be maintained as per project specifications. It is important that quality requirements be satisfied and production schedules are met. The satisfaction of the owner of the project is mainly derived by the quality of the work. Stiff competition in the national and international level of construction sector demands a high quality oriented attitude of engineers. However, the management is required to achieve the satisfaction of the owner by completing the project within the cost constraints for the project. Both of these things are dependent on properly integrating quality development, quality maintenance and quality improvement in construction.

Quality

Quality is a relative term and is used with reference to the end use of the product. In the context of the construction field, this end product is what we construct. Sometimes quality is defined as the fitness of any constructed facility or structure for use at the most economical level. As there may be difference in the perception of quality of an object, we have to specify the quality in a clear term. As mentioned above, quality may sometimes mean as the fitness for use. Sometimes it may be interpreted in terms of conforming to requirements. For example, a tourist building must be planned so that people staying inside it must feel its aesthetic appeal or beauty. If it does not conform to this requirement some people may term it not conforming (or matching) to the requirements. Sometimes quality may be interpreted in terms of grade or degree of excellence for some structures. The quality of construction of a project is also dependent on the quality of several other parameters. Quality of a constructed facility may be verified based on some instincts or factors.

These may be considered as follows :

The integration of all these three aspects can be achieved through a sound quality control system.

• Aesthetics
• Strength
• Durability
• Safety
• Economy
• Maintainability
• Reliability
• Degree of satisfaction of the end user
• Versatility of use for many purposes

Quality of Design

Quality of design of a construction is concerned with the specifications which have to be conformed with. A good quality of design must ensure consistent performance of the facility for the entire life span of the facility. The design of the facility should be done in such a way that all possible modes of failures are considered and appropriate inputs are ingrained in the design to take care of them. Quality design is a continuous process which results in good evaluation of an end product. Design features which are essential for a project are necessary to be considered. For example, a road without design features such as camber, superelevation or provision of side drains is not going to be evaluated as a good construction. Objectives of the owner for the construction of a structure, cost considerations, environmental considerations, etc. are some of the factors which may affect the design of a structure and hence its quality.

Conforming to Quality

Conforming to quality means the quality of the product/construction to be of a required order. It is essential so that the construction goes on as per the satisfaction of the owner. Use of proper quality of materials, proper work sequences, proper types of equipment and inspections from time to time are factors which should be considered. It is to note that a higher quality of design increases the cost but a higher quality of conformity with the design saves the investment.

Quality of Performance

It is connected with how well the constructed facility gives its performance. It depends on both the quality of design and the quality of conformance. It may be easily understood that even a best design may not be able to provide us with something which is going to be the best in terms of performance if the quality of conformance is poor. The reverse is also true. A proper quality of conformance also cannot provide a good quality of constructed facility if the quality of design of the facility is not good.

Characteristics of Quality

Quality of a particular object, such as a car, a book or a building, may be assessed by some parameters which are physical or chemical in nature. Sometimes the criteria may be abstract such as aesthetics or beauty of an object. These parameters are used to define the quality of an object. Quality characteristics may be defined in terms of parameters which may be of the following types:

- Technical parameters – length, viscosity, etc.
- Psychological parameters – taste, beauty, etc.
- Time parameters – speed, life span, etc.
- Contractual parameters – safety, reliability, etc.
- Ethical parameters – honesty, integrity, nature, etc.

These characteristics may be measurable or non-measurable. This may be another criterion for classifying those parameters which may assess quality.

Quality control may be defined as a procedure by which we compare the actual quality of an object with the intended quality. If the actual quality is different from the intended one, especially if it is less, we have to take corrective actions. The intended quality is defined by some characteristics. The same characteristics of the actual object are measured. When these characteristics are compared, we can have an idea of whether the actual quality of the object is acceptable. Quality control may be termed also as a systematic control of those factors which define the quality of an object. For example, we know that the strength of a structural member, such as a column, is dependent on the quality of materials which are used to construct that column. We shall have to control the quality of materials to control the quality of column. Quality control includes all such procedures, tools, specifications and the system of norms & specifications which are used to control the quality of an object.

Quality control is generally costly. We have to train people for making inspections, assessing quality of objects with the help of instruments which are sometimes purchase or hired on rent. Time also is spent on inspections.

Inspections may sometimes affect the progress of work. Sometimes, we may have to dismantle some construction or part of construction which may be a drain on the resources of an organization. The cost of quality assurance should be considered and it should be the practice on the part of the contractor to establish high quality standards. Sometimes disputes may be there because of decisions made during inspections which have to be sorted out. Getting these disputes amicably resolved also may sometimes be time consuming and costly.

There are some benefits of maintaining quality in the construction. These may be expressed as below

- Increase in efficiency because of quality consciousness
- Reduction of scrap due to less number of items being rejected
- Easy identification of construction faults
- Decrease in cost in the long run due to benefits of quality control
- Creating quality consciousness in workers

PRINCIPLES OF INSPECTION

Inspection means the checking of material or product at various stages of manufacture or construction of an object. It is done with respect to some pre-defined parameters and it tries to detect the faulty nature of the object. When we inspect something, we try to see the past history of construction and try to learn from our past experiences. Faulty objects are sorted out and are rejected. For example, those structural members, whose construction has been faulty, may be dismantled and reconstructed. There may be different aspects which may be followed. For example, the quality of a beam specimen may be faulty because the concrete in that beam may not be of the chosen grade. It may be considered faulty if the detailing of reinforcement (i.e. how the reinforcement is to be placed in the beam) also is faulty. Such beam members would be discarded, dismantled and reconstructed.

Inspection should not be confused with quality control. Inspection is a way or method of maintaining the quality of the object being constructed or produced. Controlling the quality is what is termed as quality control. Quality control is a wide term which involves inspections at various stages of construction. Basically, when we consider the quality control of some object, we always have some future object in mind and we try to find out the ways as to how to control the quality of that object, to be produced in future. This is why, the quality control people are provided with instructions prior to the production or construction of some object or some building. Inspections give us needed inputs to control quality. If the quality of an object is found to be not as per expectations, we have to take remedial steps. Inspections check the quality of past constructions and quality control norms or specifications are provided for the future constructions. Inspection is an act of checking the objects or items, sorting out and finding out the faulty item. Quality control is a broad term which includes inspection as an activity out of a number of activities carried out for the purpose.

Inspections are carried out using precise equipment and instruments. These devices or tools are used to measure those characteristics which define the quality of an object. Using such devices, we can ascertain the quality of past constructions and judge if those objects, which were constructed, were as per accepted norms and specifications. Inspection is mainly carried out by people who are responsible for it. They must know the norms and specifications, characteristics to be measured and should know how to use different devices and tools to examine the quality of a construction. For inspecting the quality of construction, non-destructive test procedures have been established. In such procedures, which are termed as NDT procedures, we can test the quality of construction without deforming a structural element.

MAJOR ITEMS IN CONSTRUCTION JOB REQUIRING QUALITY CONTROL

To understand the aspect of quality control in construction, it has to appreciate that construction industry is somewhat different from other manufacturing industries. The objects created or constructed in this sector are most of the times unique in the sense that the structures are never the same or the exact replica of one another. Two buildings, two bridges, two roads may be chosen at random and in each case we would find that there are differences or variations. There are certain considerations which should be kept in mind when we consider quality control in civil engineering construction.

Quality of construction is dependent, to a great extent, on

- The quality of materials which are used in construction
- The expertise of workers
- The technology adopted in construction
- Number, type and quality of inspections
- Quality consciousness of people
- Funds available for construction and quality control
- Time available for quality control procedures
- Existence of norms and guidelines for assessing quality of construction of a particular type
- Experience and expertise of inspectors
- Quality of design
- Nature of the construction project

We can see that some activities in a construction work may be of a repetitive nature. Some activities are taken up only for some times. Concrete mix making may be a routine affair at a construction site. We can understand that quality control norms may be different when we compare two materials out of which one is a factory made item and the other one is a site made material. It may be the case of some steel channel section and the concrete mix. We should be

more concerned for the quality control exercised for the making of materials which are manufactured at the site. This is due to the reason that illiterate workers may not know the correct manner of doing something in a right way. For some materials, we have to be extra vigilant for quality as these materials may be very important for supplying strength to the construction. If the quality of concrete is not good, we cannot expect a good quality of construction. Quality of construction materials should be good. Guidelines should be followed in the assessment of quality of these materials. Some common materials which are used for construction are given below:

- Cement
- Fine and coarse aggregates
- Chemical admixtures
- Timber
- Steel
- Soil of a site
- Bricks and stones

Standard guidelines, formed by standard codes, are available. These guidelines supply us with the tests conducted to assess the quality of these materials. Tests should be conducted on these materials and faulty materials should not be used. Quality of construction procedures and processes adopted also should be considered in the context of quality control.

STAGES OF INSPECTION AND QUALITY CONTROL

Specifications for quality are available in Indian standards formulated by Bureau of Indian Standards, New Delhi. Different types of construction works are dealt with in different ways and different tests to assess their different quality characteristics are available. In different types of construction works or jobs different stages may be recognized. For example, if we wish to make a reinforced concrete beam structural member, we have to go through different stages such as providing supports to the form work, making of form work, cutting or reinforced bars for the beam, putting the reinforcement in the formwork, mixing of concrete, pouring of concrete in the formwork, vibrating concrete, curing concrete, etc. There are different types of guidelines to oversee each stage so that the quality of the beam is of a right type. We should appreciate that it shall be difficult to maintain the overall quality if quality is not maintained in some of these stages. We have to monitor quality of each and every stage to get the required quality of the concrete member.

Salient points are given below regarding different stages and quality control aspects required to be considered in some general construction operations.

Earth Work

Stages

• Measurement of dimensions in different directions in terms of height, width and length

• Excavation of soil

• Determination of soil properties

• Compacting soil

Quality Control Considerations

• Accurate measurements with precise instruments

• Use of good equipment

• Use of standard procedures for testing of soil

• Use of equipment for compaction

Masonry

Stages

• Measurement of dimensions in different directions in terms of height, width and length

• Construction of masonry

• Curing of masonry work

Quality Control Considerations

• Use of good quality materials

• Use of right construction procedures and correct bonds

• Employment of people with experience and expertise

• Adequate curing of masonry

Reinforced Cement Concrete (RCC)

Stages

• Measurement of dimensions in different directions in terms of height, width and length

• Creation and installation of formwork

• Provision of reinforcement

• Mixing of concrete

• Casting of concrete

• Curing of concrete

Quality Control Considerations

• Use of good quality materials

• Use of right construction procedures

• Employment of people with experience and expertise

• Correct detailing of reinforcement

• Adequate curing of concrete

Sanitary and Water Supply Services

Stages

• Measurement of dimensions in different direction in terms of length as well as area covered

• Procurement of sanitary and water supply items

• Installation of these items correctly

• Testing of these items

Quality Control Considerations

• Use of good quality materials and items

• Use of right construction procedures

• Employment of people with experience and expertise

Electrical Services

Stages

• Measurement of dimensions in different direction in terms of length as well as area covered

• Procurement of items

• Installation of these items correctly

• Testing of these items

Quality Control Considerations

• Use of good quality materials and items

• Use of right connection procedures

• Employment of people with experience and expertise

Various types of effects, due to inadequate quality control in construction, generally seen in various facilities already constructed are provided in Table.

Cause/Effect	**Ponding of Water Taking Place in a Slab**
Remedy/Precaution	The effect of ponding may be due to insufficient slope provided in the slab. This may create problems while washing floors. If ponding takes place in the topmost slab, it may be even more troublesome in the rainy season.

Cause/Effect	Cracks Appearing in Concrete Structural Members in a Structure
Remedy/Precaution	The reinforcement detailing in the structural members of concrete should be correctly provided as a precaution. If the cracks are detected, proper safeguards should be taken with the expert advice. In any case, cracks should be properly sealed so that corrosion of reinforcement inside does not occur.
Cause/Effect	**Peeling Off of Plaster, Crumbling of Concrete of Structural Members**
Remedy/Precaution	Plastering of the surface should be redone in the area where the peeling off has taken place. Fresh cover concrete from where crumbling of crumbling of concrete is considered as a falling hazard also.
Cause/Effect	**Efflorescence in Walls, Peeling of Plaster, Corrosion of Cement, Plaster of the Walls**
Remedy/Precaution	Efflorescence may be due to seepage in the walls. The seepage in the walls should be arrested. Portions, where plaster has peeled off, should be replastered. Wall portions where plaster has lost its strength may be subject to guniting or may be reconstructed.
Cause/Effect	**Walls of Great Thickness Showing Rupture, along the Length of Wall, in the Middle Portion**
Remedy/Precaution	Walls may be provided with through stones or reinforcement bars going along the thickness of walls. This gives them safety in vibratory situations such as earthquakes.
Cause/Effect	**Walls having Less Strengths in certain Portions, such as Near Corners, Walls of Large Slenderness Ratio**
Remedy/Precaution	Proper bond should be provided in the walls, especially where two walls meet. Walls of large slenderness ratio should be strengthened as under earthquakes or under impact loads these may fail and cause accidents. Such walls may preferably be reinforced.

Cause/Effect	**Leakage Due to Water Tank, Seepage at the Top of Mumty Slab especially in Rainy Season**
Remedy/Precaution	Leakage of water from the water tank should be arrested. Pipe joints should be checked and faulty ones should be repaired. Mumty slabs should be repaired to avoid ponding of water.
Cause/Effect	**Falling Hazards Due to Parapet Walls and Water Tanks at the Top**
Remedy/Precaution	Parapet walls should be repaired to give them added strength. They may be reinforced during reconstruction. The pillars of water tanks should be made of adequate strength so that they can take the shear stresses during earthquake conditions.
Cause/Effect	**Seepage from Water Tank Walls**
Remedy/Precaution	The walls of the water tanks should be repaired suitably. Ferrocement treatment may be given to the walls of tanks to make them impervious to water concrete has taken place in the structural elements should be provided.

TOTAL QUALITY MANAGEMENT (TQM)

Total Quality Management (TQM) can be defined as the process in which top management along with other people of the organization works to improve the quality of products and work environment continuously at all stages and at all levels with the aim to improve satisfaction of customers and employees.

Concepts of TQM

1. Top management should be aware and committed towards implementation of TQM
2. Focus on customer satisfaction and quality of products.
3. Involve employees in understanding quality aspects.
4. Continuous improvement is required.
5. Treat suppliers as your partners.
6. Develop tracking mechanism for processes.

Characteristics of TQM.

1. Customer Focused.

The customer ultimately determines the level of quality. No matter what organisation does to improve quality, the customer determines whether the efforts were worthwhile.

2. Total employee involvement.

All employee should participate in working towards the common goal of the organization. Total employee commitment can only be obtained, if the management provided proper working environment.

(2) 3. Process - Centered.

A process is a series of steps that take inputs (raw materials) from suppliers and transforms them into outputs (products). The steps required to carry out these processes should be defined and performance should be measured at each stage.

4. Integrated System.

In an organisation, there are many vertically structured departments. But in TQM, the horizontal processes connecting these departments should be focussed.

5. Strategic & Systematic approach.

It includes the formulation of strategic plans that is focused on quality.

6. Continual Improvement.

TQM focusses on continual improvement at all stages and at all levels to meet stakeholders expectations.

7. Fact based decision making.

TQM requires an organization to continually collect and analyze (data) in order to improve decision making.

8. Communications.

Effective communication plays a large part in maintaining morale and in motivating employees at all levels.

Elements of TQM.

To be succesful in implementing TQM, concentrate on the following eight key elements.

1. Ethics
2. Integrity
3. Trust
4. Training
5. Teamwork
6. Leadership
7. Recognition
8. Communication

These eight elements can be grouped into four categories according to their functions.

1. Foundation → Ethics, Integrity, Trust.
2. Building Blocks → Training, Teamwork and Leadership
3. Binding Mortar → Communication
4. Roof → Recognition.

I- Foundation

TQM is build on a foundation of ethics, integrity and trust. It improves fairness, openness and sincerity.

(1) Ethics.

Ethics is represented by organization ethics and individual ethics. Organizational ethics establish a business code of conduct & ethics. Individual ethics includes personal rights or wrongs.

(4)

② Integrity.

Integrity implies honesty, morals and values.

③ Trust

Trust is a byproduct of ethics and integrity. Without trust TQM cannot be built in an organization.

II - Bricks

④ Training.

Training is very important for employees to be highly productive. Supervisors should teach their employees the philosophies of TQM.

⑤ Teamwork.

Without good teamwork between the management and employees, the philosophies of TQM cannot be successful.

⑥ Leadership.

For TQM to be succesful in business, the supervisor must be committed in leading his employees.

III - Binding Mortar.

⑦ Communication.

It acts as a vital link b/w all elements of TQM.

There are different ways of communication

1) Downward Communication → Supervisors/Management are able to make the employees clear about TQM.

2) Upward Communication → Lower level of employees are able to provide suggestions to top management about affects of TQM.

3) Sideways Communication → It breaksdown interdepartment barriers. Also allows communications between in customer and suppliers in a more professional manner.

IV - Roof

⑧ Recognition.

Supervisors should detect and recognize contributors to TQM. They must be rewarded and appreciated.

Principles of TQM.

1. Add value to the process.

Every action of every employee should add value to the process and product.

2. Deliver quality on time all time

Always deliver quality products and services on time.

3. Base business relationship on mutual trust and confidence.

Providers and suppliers should build trust and confidence through quality and deliverability.

4. Train individuals and teams to solve problems.

Use problem solving tools and techniques as means to solve quality.

5. Empower Employees.

Empower employees about ideas of TQM.

6. Need ownership of process to employees.

Rewards and appreciation in terms of incentives, job security and equal sharing should be given to contributors of TQM.

7. Implement new technologies.

Use new techniques to eliminate errors and to improve productivity.

8. Collect, measure and evaluate data.

Make decisions based on measurement of quality.

9. Apply 80/20 principle.

ie 20% of the causes create 80% of the problems.

Identify the causes and rectify it.

10. Develop win-win scenarios.

Good teamwork will benefit all the parties.

11. Develop a master plan.

Quality begins at design level. Include concepts of TQM starting from design stage.

12. Plan for all contingencies.

Prepare for unforeseen happenings. Create alternatives.

13. Make zero defects and accidents your goal.

Achieve goals by detecting and eliminating the causes.

14. Qualify your sources and suppliers.

Use quality and deliverability as basis in selecting Sources and Suppliers.

15. Deliverability.

Right product should be delivered at the right time.

16. Meet needs of your customer.

Deliver products that meet or exceeds the requirement of your customer.

17. Improve Continuously and Always.

Organization should practice continuous improvement through TQM.

Implementation of TQM.

Implementation of TQM is a fourteen step procedure:- →

1. Management Commitment.

Management should declare their policy on quality needs. It should be simple and easily understandable for the employees. The quality should be also discussed regularly in management review meetings.

2. Quality Improvement team.

The members of quality improvement team should help employees in quality improvement activities.

3. Measurement.

The improvement in quality should be measurable. The quality improvement teams must decide ways to measure quality.

4. Cost of quality.

The quality improvement team should implement methods to measure non conformance (defects) and minimise the same to achieve 'Zero defect' (do it right the first time).

5. Quality Awareness.

The quality improvement team should create education and training programmes to create awareness about quality.

6. Corrective Action.

The quality improvement team should plan corrective measures to reduce cost of non-conformance (defects).

7. Zero Defect Planning.

The quality improvement team should plan for zero defects.

8. Employee Education.

The quality improvement team along with consultants should impart training and education on quality improvement tools.

9. Zero defect days.

The quality improvement team should plan for zero defect days.

10. Goal Setting.

The quality improvement team should help in attaining individual and organizational goals.

11. Errors Cause Removal

The quality improvement team should find out root cause of the problems and take preventive actions against it.

12. Recognization.

The quality improvement team should recognize the efforts taken by the employees in improving quality by giving them awards, incentives, promotions etc.

13. Quality Council.

The quality improvement team should submit periodic report to quality council. The quality council will discuss all the quality improvement activities and take decisions on them.

14. Do it over again.

The quality improvement team takes the plans adopted for a successful project and implements on other quality improvement projects.

Advantages of TQM

* Strengthened competative position
* Higher productivity
* Enhanced market image
* Elimination of waste and defects.
* High profitability
* Reduced cost and better cost management
* Improved customer satisfaction.
* Increased job security.

Barriers to implementing TQM.

* Lack of management commitment
* Plans not working out
* Lack of teamwork
* Lack of training.
* Lack of communication.
* Focuses only on short term profits
* Management doesnot reward success.
* Insecurity in job.