

# ESTIMATING AND COSTING IN ELECTRICAL ENGINEERING

## ***LEARNING OUTCOME***

After undergoing the subject, student will be able to:

- Determine various types of wiring systems and how they are being used
- Practice and execute any type of wiring
- Estimate and determine the cost of wiring installation
- Estimate the material required for HT and LT lines
- Prepare a tender document for a particular job
- Estimate the material required for pole-mounted sub-stations

## **Chapter:1**

### ***1. Introduction***

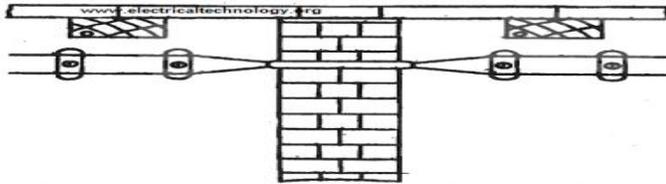
Purpose of estimating and costing, proforma for making estimates, preparation of materials schedule, costing, price list, preparation of tender document (with 2-3 exercises), net price list, market survey, overhead charges, labour charges, electrical point method and fixed percentage method, contingency, profit, purchase system, enquiries, comparative statements, orders for supply, payment of bills.

### ***1.1 Types of Wiring***

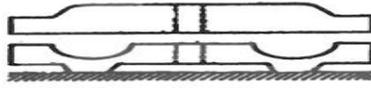
#### ***1.2 Cleat Wiring***

This system of wiring comprise of ordinary VIR or PVC insulated wires (occasionally, sheathed and weather proof cable) braided and compounded held on walls or ceilings by means of porcelain cleats, Plastic or wood.

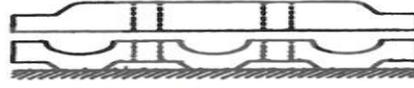
Cleat wiring system is a temporary wiring system therefore it is not suitable for domestic premises. The use of cleat wiring system is over nowadays.



Use of Wall tube, wires are drawn from one room into the other through partition wall.



I. Cleat with two grooves



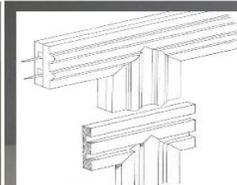
II. Cleat with three grooves



**Cleat Wiring**

### 1.3 Casing and Capping wiring

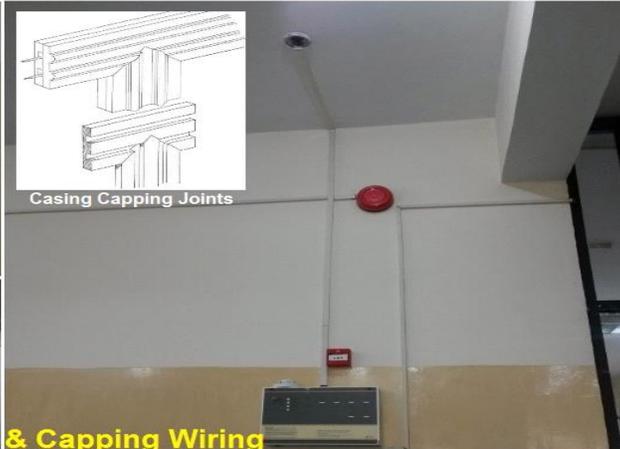
Casing and Capping wiring system was famous wiring system in the past but, it is considered obsolete these days because of Conduit and sheathed wiring system. The cables used in this kind of wiring were either VIR or PVC or any other approved insulated cables. The cables were carried through the wooden casing enclosures. The casing is made up of a strip of wood with parallel grooves cut length wise so as to accommodate VIR cables. The grooves were made to separate opposite polarity. The capping (also made of wood) used to cover the wires and cables installed and fitted in the casing



Casing Capping Joints



**Casing & Capping Wiring**



### 3. Batten Wiring (CTS or TRS)

Single core or double core or three core TRS cables with a circular oval shape cables are used in this kind of wiring. Mostly, single core cables are preferred. TRS cables are chemical proof, water proof, steam proof, but are slightly affected by lubricating oil. The TRS cables are run on well seasoned and straight teak wood batten with at least a thickness of 10mm. The cables are held on the wooden batten by means of tinned brass link clips (buckle clip) already fixed on the batten with brass pins and spaced at an interval of 10cm for horizontal runs and 15cm for vertical runs.



#### ***4. Conduit Wiring***

There are two additional types of conduit wiring according to pipe installation.

- **Surface Conduit Wiring**
- **Concealed Conduit Wiring**

#### **Surface Conduit Wiring**

If conduits installed on roof or wall, It is known as surface conduit wiring. in this wiring method, they make holes on the surface of wall on equal distances and conduit is installed then with the help of rawal plugs.

#### ***Concealed Conduit wiring***

If the conduits is hidden inside the wall slots with the help of plastering, it is called concealed conduit wiring. In other words, the electrical wiring system inside wall, roof or floor with the help of plastic or metallic piping is called concealed conduit wiring. obviously, It is the most popular, beautiful, stronger and common electrical wiring system nowadays.



In conduit wiring, steel tubes known as conduits are installed on the surface of walls by means of pipe hooks (surface conduit wiring) or buried in walls under plaster and VIR or PVC cables are afterwards drawn by means of a GI wire of size if about 18SWG.

In Conduit wiring system, The conduits should be electrically continuous and connected to earth at some suitable points in case of steel conduit. Conduit wiring is a professional way of wiring a building. Mostly PVC conduits are used in domestic wiring.

The conduit protects the cables from being damaged by rodents (when rodents bites the cables it will cause short circuit) that is why circuit breakers are in place though but hey! Prevention is better than cure. Lead conduits are used in factories or when the building is prone to fire accident. Trunking is more of like surface conduit wiring. It's gaining popularity too.

It is done by screwing a PVC trunking pipe to a wall then passing the cables through the pipe. The cables in conduit should not be too tight. Space factor have to be put into consideration.

### ***Types of Conduit***

Following conduits are used in the conduit wiring systems (both concealed and surface conduit wiring) which are shown in the above image.

. ***Metallic Conduit***

. ***Non-metallic conduit***

#### ***Metallic Conduit:***

Metallic conduits are made of steel which are very strong but costly as well.

There are two types of metallic conduits.

Class A Conduit: Low gauge conduit (Thin layer steel sheet conduit)

Class B Conduit: High gauge conduit (Thick sheet of steel conduit)

### Non-metallic Conduit:

A solid PVC conduit is used as non-metallic conduit now a days, which is flexible and easy to bend.

### Size of Conduit:

The common conduit pipes are available in different sizes genially, 13, 16.2, 18.75, 20, 25, 37, 50, and 63 mm (diameter) or 1/2, 5/8, 3/4, 1, 1.25, 1.5, and 2 inch in diameter.

### Comparison between Different Wiring Systems

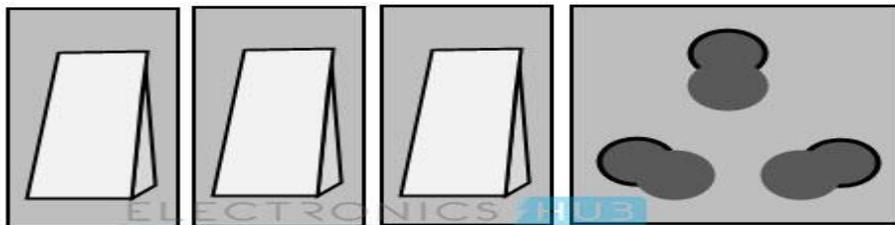
Below is the table which shows the comparison between all the above mentioned wiring systems.

S.No	Particulars <small>© www.electricaltechnology.org</small>	Cleat Wiring	Casing Capping Wiring	Batten Wiring	Conduit Wiring
1	Life	Short	Fairly long	Long	Very long
2	Cost	Low	Medium	Medium	Highest
3	Mechanical Protection	None	Fair	None	Very good
4	Possibility of fire	Nil	Good	Good	Nil
5	Protection from dampness	None	Slight / a little	None	Good
6	Type of labor required	Semi-Skilled	Highiy Skilled	Semi-skilled	Highly Skilled
7	Installation	Very Easy	Difficult	Easy	Difficult
8	Inspection	Easy	Easy	Easy	Difficult
9	Repair	Easy	Little bit difficult	Easy	Difficult
10	Popularity	Nil	Fair	Nil	Very High

**Comparison of Different Wiring Systems**

## 5. Electrical Wiring Systems and Methods of Electrical Wiring

The electrical wiring must be installed correctly and safely in accordance with electrical regulations and standards. If the electrical wiring is carried incorrectly or without confirming to any standard, devices could damage or leads to the malfunctioning of device which further causes for the reduction of device life.

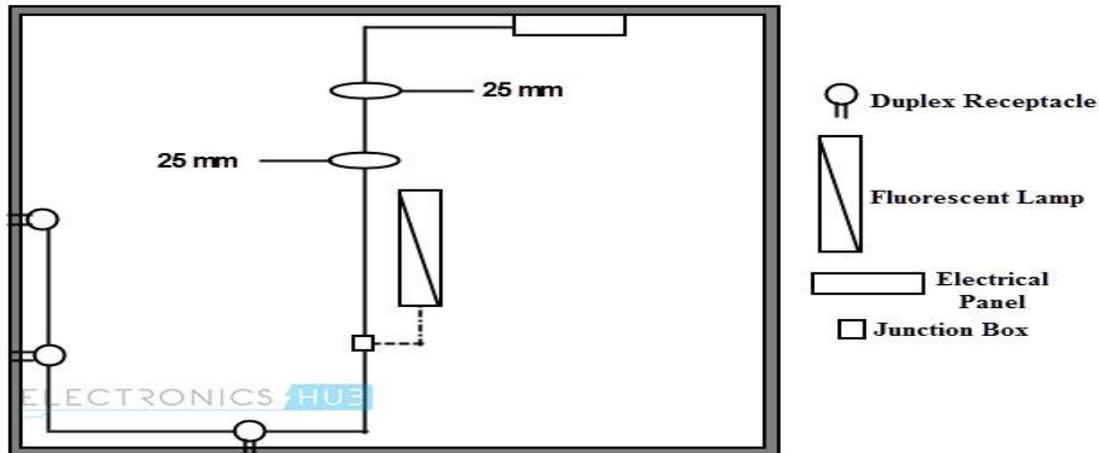


Several factors have to be considered before the actual installation work to be done for

residential, commercial or industrial wiring. These factors include type of building construction, type of ceiling, wall and floor construction, wiring methods, installation requirements, etc.

### Circuit Drawing (Diagram)

In this, electrical circuit is graphically represented in a simplified manner. It includes the position information (in cm or m or mm) of various elements like light fixtures, receptacle boxes, junction boxes, ceiling fans, etc



## 6. Domestic And Industrial Wiring.

### . Domestic wiring:

- The electric power line enters our house through three wires- namely the live wire, the neutral wire and the earth wire. To avoid confusion we follow a color code for insulating these wires.
- The red wire is the live wire, and the black wire is neutral. The earth wire is given green plastic insulation.
- The live wire has a high potential of 220 volts whereas the neutral wire has zero potential. Thus the potential difference between the live wire and the neutral wire is 220-0 220 volts.
- The earth wire is much thicker in size and is made of copper. One end of it is connected to a copper plate buried deep under the earth. The earth connection is made to the electric meter and then to the main switch.

## **.Industrial Wiring**

- To increase the productivity and to avoid the accident hazardous, factory lighting should fulfill the following requirements.
- i It should produce sufficient illumination on the working plane.
- ii It should provide uniform distribution of illumination.
- iii It should avoid glare and shadows.
- iv It should be easy to clean.

## **7. Use of wire-gauge**

**Wire gauge** is a measurement of wire diameter. This determines the amount of electric current a wire can safely carry, as well as its electrical resistance and weight.



## **Chapter:2**

### **Estimating and Costing**

#### **2.1 Domestic installations:**

Using the very latest in technology and we can build you a complete wiring installation to suit your home. We design breathtaking lighting systems which can be coupled to home automation for a totally modern yet warm ambience. The wide range of lighting now available with LED technology is now very cost effective with lower purchase costs and lower energy usage which is good for the environment.

We have worked with reknowned widely acclaimed architects to deliver a complete turnkey package from its conception to fruition for many satisfied clients. You can rest assured that all our engineers are trained to the very highest standards and possess the qualifications to carry out the job at hand. We certify each and every installation we work on and register it with the local authority having jurisdiction.

## . IE rules

Indian Electricity Rules, 2005 defines the basic fundamentals of Electricity Safety, and when followed in totality there cannot be any incidence of electrocution or electric fire.

General Safety requirements are given in Chapter IV under rules 29 to 46 which covers installation, protection, operation, maintenance cut-out, identification of earth, earthed terminal, danger notice etc.

General Rule 29 covers installation shall be constructed, installed, protected, worked and maintained in accordance with BIS. It further stipulates that the material and equipment used shall conform to the relevant specifications of the BIS.

## . IS rule

In the field of electrical engineering, engineers and other professionals get exposed to electricity indirectly during generation, transportation, installation and usage. Such conditions might cause hazards if accurate safety measures are not taken.

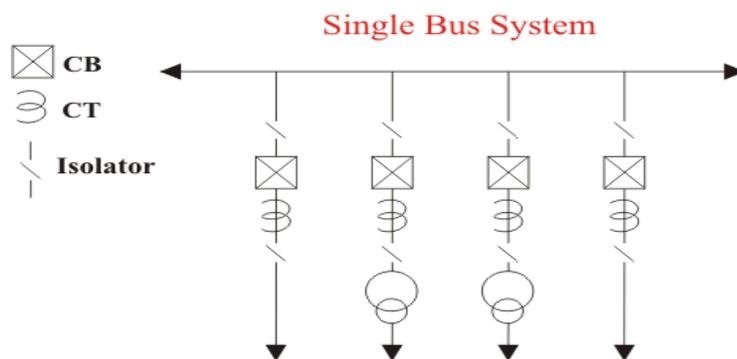
To promote the safety and the right usage of equipment, there are certain rules and regulations formulated by the Bureau of Indian Standards.

## . Planning Of Circuits

The interconnection of various active and passive components in a prescribed manner to form a closed path is called an **electric circuit**. The system in which electric current can flow from the source to the load and then back to the other terminal of the source is referred to as an **electric circuit**

## . Electrical Layout

There are many different **electrical bus system** schemes available but selection of a particular scheme depends upon the system voltage position of substation in electrical power system, flexibility needed in system and cost to be expended.



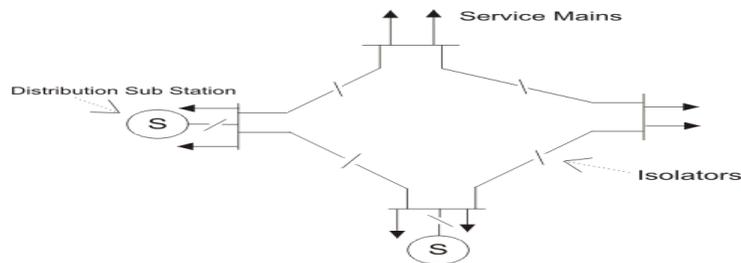
## Estimating Materials Required distribution lines

## 2.1. Transmission and

.Transmission: Various generating stations generate electrical power. These generating stations are not necessarily situated at the load center. During construction of generating station number of factors are to be considered from the economic point of view. These all factors may not be easily available at load center; hence generating stations are not normally situated very nearer to load center. Load center is the place which consumes maximum power.



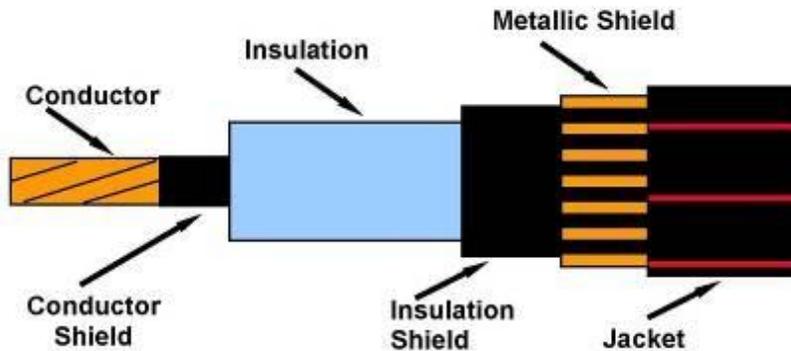
. **Distribution lines:** The main function of an **electrical power distribution system** is to provide power to individual consumer premises. Distribution of electric power to different consumers is done with much low voltage level.



### .Underground and Overhead

**Underground :**Underground cables are more expensive to construct since they have to be electrically insulated and have protection against moisture, corrosion, mechanical damage and other environmental impacts from the soil. Construction of the cables is more complicated compared to the overhead cables which are simple to construct, and do not require insulation and sheathing. The overhead cables have lesser requirements and cheaper to construct.

## Underground Cable Construction



### . Overhead

- Nobody should climb any tower carrying live overhead conductors.
- Cows or other domestic animals should not be tied with any tower legs and stay wires.
- Nobody should be allowed to throw any metallic strip, metallic wire, ropes and green twinges to the live over head lines.
- If any conductor is snapped or dangling from the tower, should not be touched without proper shutdown and temporary earthing arrangement. In this case nobody should be allowed to come closer to the snapped or hanged conductor until the entire circuit is isolated and earthed from both ends substations. In additions to that the snapped conductors should also be locally temporarily earthed with proper earthing rod before touching it for repairing work.
- If we see any sparking on the live conducting parts of over head system, we should immediately inform to the concerned authority.



### . Earthing

The main reason for doing earthing in electrical network is for the safety. When all metallic parts in electrical equipments are grounded then if the insulation inside the equipments fails there are no dangerous voltages present in the equipment case. If the live wire touches the grounded case then the circuit is effectively shorted and fuse will immediately blow. When the fuse is blown then the dangerous voltages are away.

#### 1) Plate type Earthing

- Generally for plate type earthing normal Practice is to use
- Cast iron plate of size 600 mm x600 mm x12 mm. OR
- Galvanized iron plate of size 600 mm x600 mm x6 mm. OR
- Copper plate of size 600 mm \* 600 mm \* 3.15 mm

## 2) Pipe type Earthing:

- For Pipe type earthing normal practice is to use
- GI pipe [C-class] of 75 mm diameter, 10 feet long welded with 75 mm diameter GI flange having 6 numbers of holes for the connection of earth wires and inserted in ground by auger method.
- These types of earth pit are generally filled with alternate layer of charcoal & salt or earth reactivation compound.

## 2.2 Substation: Types of substations

**.Substation:** Substation is a place or station which is used to transmit & distribute the power. It is a middle part of the electrical power generation and consumers. It contains many electrical devices such as electrical panels, transformers, insulator, isolators, GOS, Earth switch etc. In Substations we can transform the voltage from high to low, or low to high. A substation may include transformers to change voltage levels between high transmission voltages and lower distribution voltages, or at the interconnection of two different transmission voltages.

### **. Distribution substation:**

A distribution substation transfers power from the transmission system to the distribution system of an area. It is uneconomical to directly connect electricity consumers to the main transmission network, unless they use large amounts of power, so the distribution station reduces voltage to a level suitable for local distribution.

### **. Collector substation**

In distributed generation projects such as a wind farm, a collector substation may be required. It resembles a distribution substation although power flow is in the opposite direction, from many wind turbines up into the transmission grid. Usually for economy of construction the collector system operates around 35 kV, and the collector substation steps up voltage to a transmission voltage for the grid. The collector substation can also provide power factor correction if it is needed, metering, and control of the wind farm. In some special cases a collector substation can also contain an HVDC converter station.

### **. Converter substations**

Converter substations may be associated with HVDC converter plants, traction current, or interconnected non-synchronous networks. These stations contain power electronic devices to change the frequency of current, or else convert from alternating to direct current or the reverse. Formerly rotary converters changed frequency to interconnect two systems; nowadays such substations are rare.

## **.Railway Substation:**

Electrified railways also use substations, often distribution substations. In some cases, a conversion of the current type takes place, commonly with rectifiers for direct current (DC) trains, or rotary converters for trains using alternating current (AC) at frequencies other than that of the public grid. Sometimes they are also transmission substations or collector substations if the railway network also operates its own grid and generators to supply the other stations.

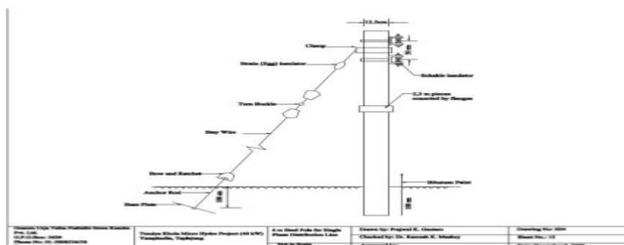
## **. Substation Schemes and Component**

The power grid is an essential element in the generation of electricity, transmission as well as distribution systems. Electrical substations are mandatory for all the processes of the power grid. These are essential devices used to generate electrical power from the substations. By changing the levels of frequency, voltage, the required amount of electricity can be changed in substations for supplying electricity to customers. An electrical substation is categorized into various types, such as generation, pole mounted, indoor, outdoor, converter, distribution, transmission, switching substations. In some cases like thermal plant, several hydroelectric, and wind farm electricity generation system, one can notice the collector substation, which can be useful for power transfer from several turbines in the only transmission unit.

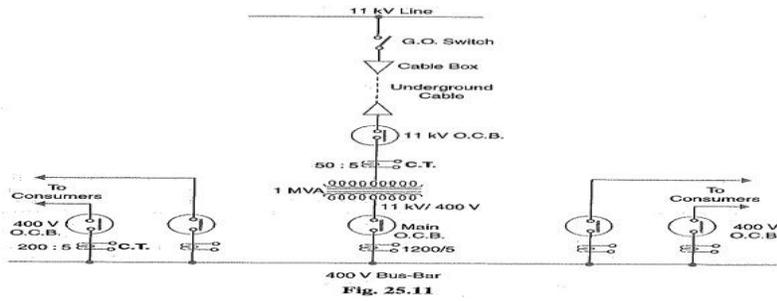
## **. Estimate of 11/0.4 kV pole mounted substation up to 200 kVA rating**

- Estimating of A Pole mounted substation Prepared By :
- INTRODUCTION Estimating is defined as a method by which we can get an approximation of the material, investment involved, and the time to be taken for the completion of Electrification project Normally it can be enlisted under following four headings. - Estimating the quantity of the material and the cost involved. - Analysis of cost or selling price. - Maintaining proper accounts. - Provision of selling aids .
- ESSENTIAL ELEMENTS OF ESTIMATING Specification of material. Latest market cost of material. Calculation of material and labour cost. Knowledge of purchase system.
- SUBSTATION Substations are serves as a source of energy supply for the local area of distribution. Their main functions are to receive energy transmitted at high voltage from the generating stations, reduce the voltage to a value appropriate for distribution and provide facilities for switching.

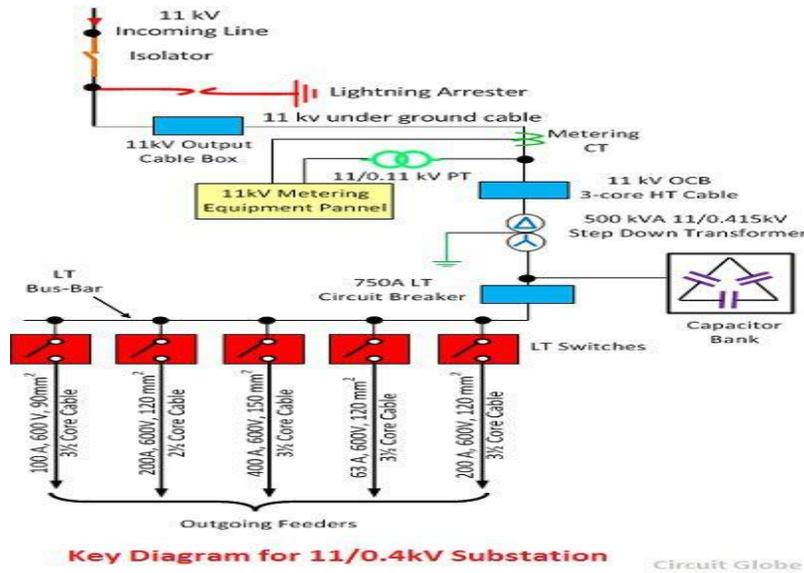
## **Typical drawings**



## **. Key Diagram of 66 kV/11 kV Substation**



### 2.3 . Single line diagram, layout sketching of outdoor



#### Indoor 11kV sub-station or 33kV sub-station

REC has issued Construction Standards L-1 and L-2 indicating the standard layout for 33/11kV sub-stations with outdoor and indoor 11kV switchgear respectively. The standard layout should be followed for all 33/11kV sub-stations in the rural distributionsystems as far as practicable. 3.3.2 The standard layout recommended by the REC is suitable for two power transformers and five outgoing 11kV feeders including two feeders for future. In case of indoor 11kV switchgear, provision has been made for four existing and two future 11kV panels and one bus-coupler panel has also been provided. The 33kV incoming arrangement will depend upon the requirement of each case, i.e. whether there are one or two incoming 33kV lines and whether any 33kV line and whether any 33kV line/lines are proposed to be taken out from the sub-station. The arrangement for the 33kV incoming and outgoing lines may be followed as per standard practice of the Board. However, an arrangement showing one incoming line and two outgoing lines has been suggested in the standard layout (shown dotted). 3.3.3 The standard layout (with out-door 11kV switchgear) shows only the general arrangement of the equipments, structures, bus bars etc., but the provision for internal roads/paths has not been shown. It is important that suitable provision is made in the switchyard depending upon the local conditions for roads/paths to facilitate transportation/shifting of the heavy equipment particularly the power transformers. It would be desirable if a truck can be taken to the site of the transformer for easy shifting of the transformer. In case of 5MVA transformers, it may be necessary to use a trailer for the purpose of transportation. It would be desirable to make provision accordingly.

## Chapter:4

### Preparation of Tender Documents

## **. Preparation of Tender Documents**

A tender is a submission made by a prospective supplier in response to an invitation to tender. It makes an offer for the supply of goods or services, including a price and proposals for how the requirements will be satisfied if these have been requested.

An invitation to tender provides prospective suppliers with tender documentation setting out the information they need to prepare their offer. It is vital that tender documents are comprehensive and clear if realistic prices are to be obtained, making it more likely that the project will adhere to the budget once the works begin, and reducing the likelihood of misunderstandings, mistakes and claims.

Tender documents might include:

- A letter of invitation to tender.
- The form of tender (formal acknowledgment that the supplier understands and accepts the terms of conditions of the tender documents).
- Preliminaries (providing a description of the project, allowing the supplier to assess costs which, whilst they do not form a part of any of the package of works required by the contract, are required by the method and circumstances of the works, such as; general plant, site staff, welfare facilities, and so on).
- The form of contract that will be used, contract conditions and any amendments. This might include a model enabling amendment if building information modelling (BIM) is being used, to make a BIM protocol part of the contract documentation.
- Employer's information requirements if BIM is being used (defining the information that will be required for the development of the project and for the operation of the completed built asset).
- A tender pricing document (or contract sum analysis on design and build projects). This sets out the way prospective suppliers should breakdown their overall tender price and is effectively an unpriced bill of quantities.
- A drawing schedule.
- Design drawings, and perhaps an existing building information model.
- Specifications.
- On construction management contracts, tender documentation for trade contracts might include the construction manager's master programme.

