2. Earthing

2.1. Introduction

The term "*EARTHING*" means connecting the *non-current carrying* metallic part of the electrical installation/equipment or the *neutral point* of supply system to the *general mass of the earth* , in such a manner that, *all* time an immediate discharge of electrical energy takes place *without danger*.

Earthing is provided

i) to ensure that no current carrying conductor to a potential with respect to general mass of earth,

ii) to avoid electric shock to the human being,

ii) to avoid risk of fire due to earth leakage through unwanted path,

In an electrical installation, if a metallic part/casing of an electrical appliance comes in contact with a bare or live wire, the metal being good conductor electricity, gets charged. Now, if any person comes in contact with this charged metal part, he/she/….will get severe shock.

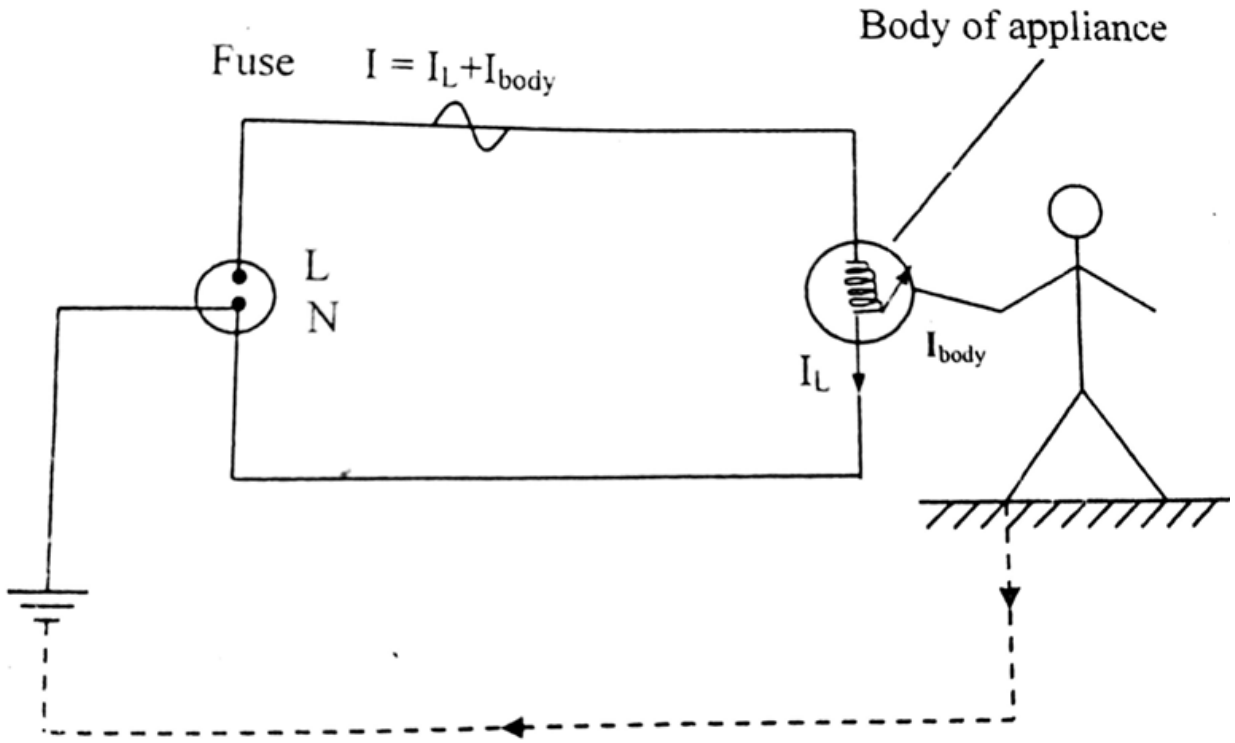


Fig. Circuit without earthing of appliance body

In this situation, the current through indivisual's body can be calculated as follows.

$$I_{body} = \frac{V}{R_{body}}$$

where, R_{body} = 10,000Ω or 10kΩ dry condition

Total current through the fuse,

$$I = I_L + I_{body}$$

Here, current I is not large enough to blowout the fuse.

But, if the metallic part of the appliances are *earthed*, the charge will be transferred to the earth immediately. And as the discharge takes place to earth, the *impedance* of path of the current is low, a *large amount* of current flows through earth. In this instant, the current exceeds the limiting value, the fuse provided in the circuit will blow off and cut off the appliance from supply.

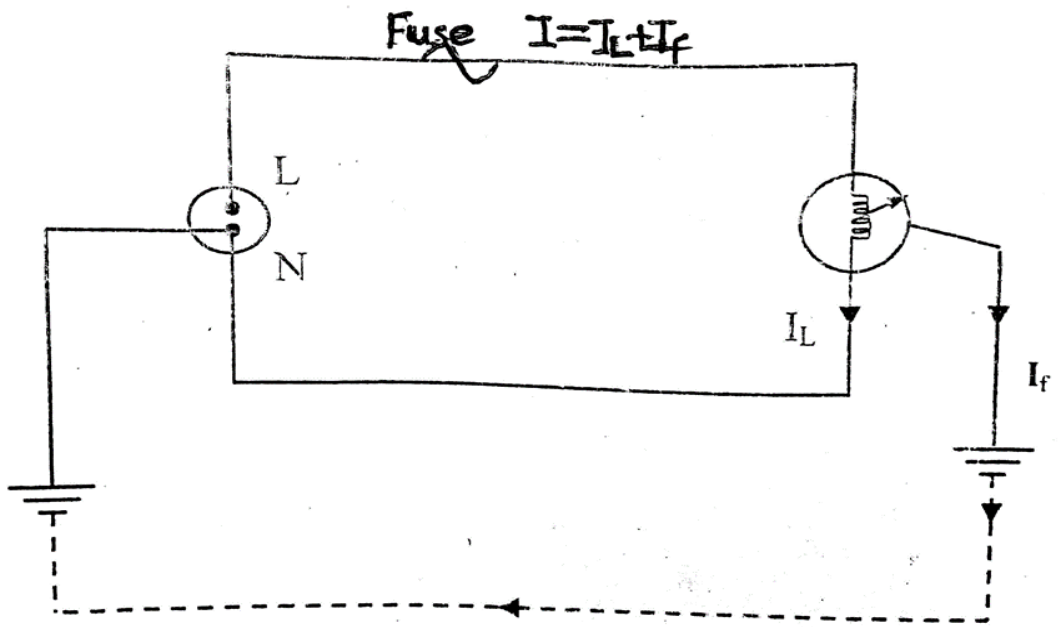


Fig. Circuit with earthing of appliance body

In this situation, the fault current through the earth can be calculated as,

$$I_f = \frac{V}{R_e}$$

where R_e = Resistance of the earthing which is very low.

Therefore, $I = I_L + I_f$ will be large enough to blowout fuse instantly before somebody comes in contact with the appliance's body.

Hence, the "*earthing*" of metallic part of electrical equipment and appliances provides *safety*.

Important specification reguarding earthing as recommended by ISI.

1. ***Distance of Earth From Building:*** An earthing electrode shall not be situated within a distance of 1.5 metres from the building whose installation system is being earthed.

2. ***Size of Earth Continuity Conductor:*** The conductor, by means of which the metal body of an equipment or appliance is connected to the earth is known as earth continuity conductor (E.C.C.) The earth continuity can be ensured either through metal conduit, metal sheathing of metal sheathed cables or by a special earth continuity conductor. The cross-section of earth continuity conductor should not be either less than 2.9 mm^2 (14 SWG.) or half of the installation conductor size.

3. ***Resistance of Earth:*** There is no hard and fast rule. The main principle regarding earth resistance is that the earth resistance should be low enough to cause flow of current sufficient to operate the protective relays or blow fuses, in the event of an earth fault. The value of earth resistance does not remain constant but changes with the weather, as it depends upon the moisture content of the soil and are maximum during dry season. As a general rule the lower the value of earth resistance better it is but even then the following values of earth resistance (maximum permissible values) will give satisfactory results.

Large power station	-	0.5 Ω
Major power station	-	1.0 Ω
Small substation	-	2.0 Ω
In all other cases	--	8.0 Ω

4. The sensitivity of the protective equipment, system voltage and the maximum fault current direc relate to permissible value of earth resistance. In case the earth resistance exceeds the permissil value, then in case of earth fault, the fault current may not reach a sufficient value to operate protective equipment (such as fuses or relays) and dangerous condition may arise.

5. The earth wire and earth electrode will be of same material.

6. The earth wire shall be taken through GI pipe of 12.7 mm of diameter for at least 30.5cm length above and below ground surface to the earth electrode to protect it against mechanical damage.

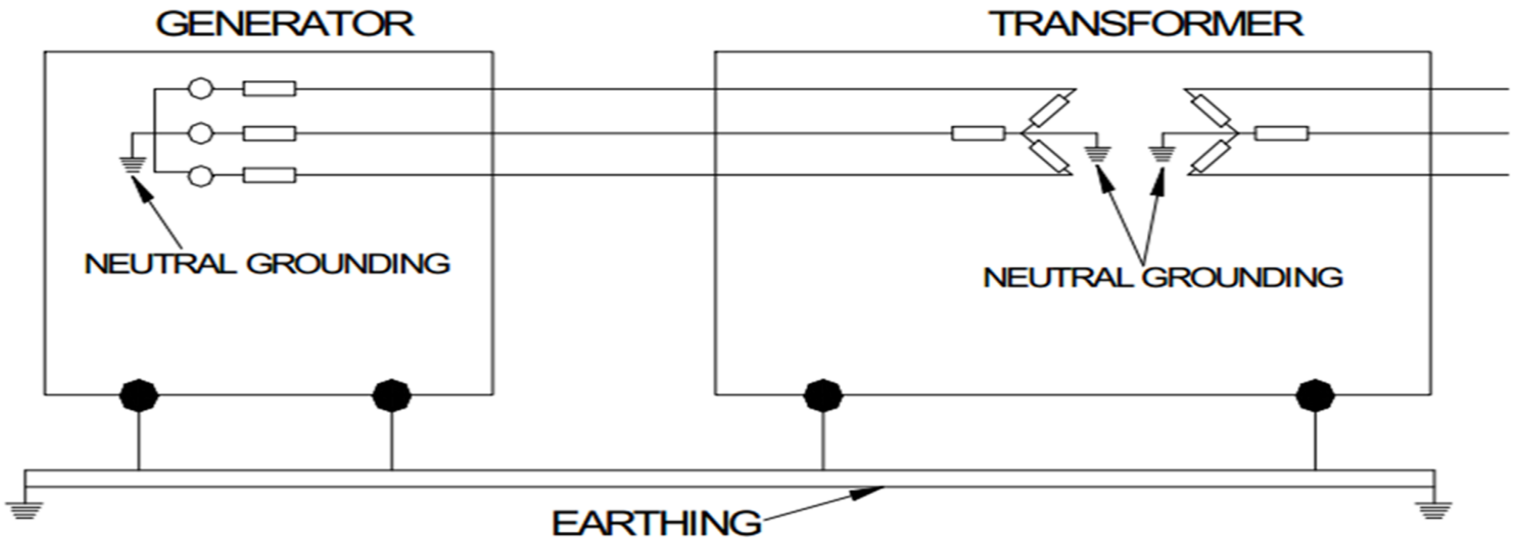
7. It is not necessary that earth wire connected to an earth electrode is run along the whole wiring system. All the earth wires run along the various sub-circuits shall be terminated and looped firmly at the main board and from main board the main earth wire shall be taken to the earth electrode. The loop earth wires used shall not be either less than 2.9 mm^2 (14 S.W.G.) or half of the size of the sub-circuit conductor.

8. This earthing electrode shall always be placed in vertical position inside the earth or pit so that it may be in contact with all the different earth layers.

2.2. System and equipment earthing

System earthing (Grounding) done to limit the potential of live conductors with respect to earth to values which the insulation of the system is designed to withstand and to ensure the security of the system.

Equipment earthing comprises earthing of all metal work of electrical equipment other than parts which are normally live or current carrying. This is done to ensure *effective operation* of the *protective gear* in the event of leakage through such metal work, the potential of which with respect to neighboring objects may attain a value which would cause danger to life or risk of fire.



2.2.1 May be in contact with all the different earth layers.

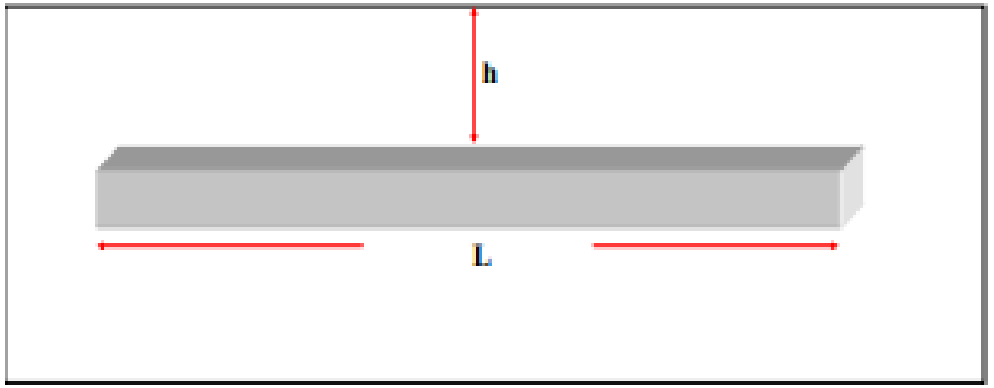
Points to be Earthed: According to Rules and Regulations:

(i) Earth pin of 3 pin lighting plug sockets and 3 and 5 pin power plug sockets should be permanently and efficiently earthed.
(ii) The metallic covering of electrical appliance must be earthened.
(iii) The metal casing of portable apparatus such as heaters, refrigerators, hand lamps, soldering irons, electric drills etc., should be connected to earth.
(iv) The frame of every generator, station motor, portable motor and the metallic parts (not intended as conductors) of all transformers should be earthed.
(v) The neutral conductor of a 3-phase, 4-wire should be earthed by not less than two separate and distinct connections with earth at the **generating station and at the substation**. It may also be earthed at one or more points along the distribution system or service line in addition to any connection with earth, which may be at the consumer's premises.
(vi) In the case of a system comprising electric supply lines having **concentric** cables, the external conductor of such cables should be earthed by two separate and distinct connections with earth.
(vii) Fabricated steel transmission line towers, tubular steel or rail poles carrying overhead conductors should be earthed. For this purpose a continuous earth wire is provided and connected with earth at four points in every one mile. (1 mile :1.61 km)

2.3 Method of earthing

1. ***Strip or Wire Earthing:*** - In this system of earthing, strip electrodes of cross-section not less than 25 mm x 1.6 mm of copper or 25 mm x 4 mm of galvanised iron or steel are buried in horizontal trenches of minimum depth 0.5 meter. If round conductors are used, their cross-sectional are shall not be smaller then 3.0 mm^2 if of copper and 6.0 mm^2 if of galvanised iron or steel. The length of buried conductor shall be sufficient to give the required earth resistance. It shall, however, be not less than 15 meters. The electrodes shall be as widely distributed as possible, preferably in a single straight or circular trench or in a number or trenches radiating from a point. If conditions requires use of morel than one strip, they shall be lain either in parallel trenches or in radial trenches.

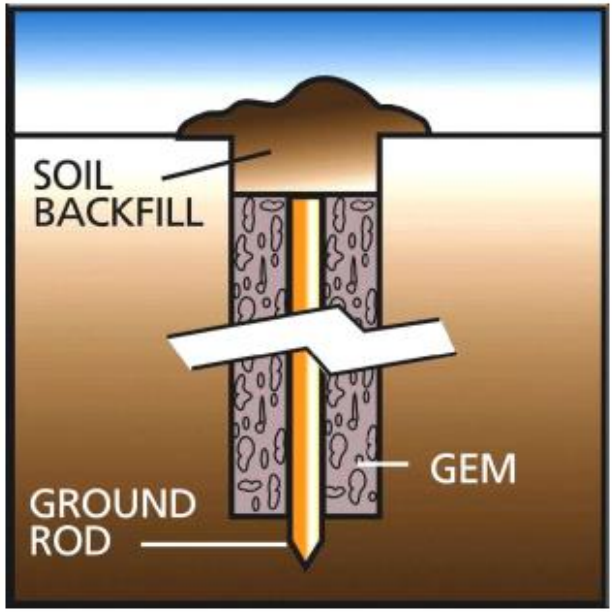
This type of earthing is used at places which have rocky soil earth bed because at such places excavation work for plate earthing is difficult.



2.3 Method of earthing

2. ***Rod Earthing:*** In this system of earthing 12.5 mm. diameter solid rods of copper or 16 mm diameter solid rods of galvanised iron or steel or hollow section 25 mm G.I. pipes of length not less than 2.5 meters are driven vertically into the earth. In order to increase the embedded length of electrodes under the ground, which is sometimes necessary to reduce the earth resistance to desired value, more than one rod sections are hammered one above the other.

This system of earthing is suitable for these areas, which are sandy in character. This system of earthing is very cheap as no excavation work is involved.



2.3 Method of earthing

3. ***Pipe Earthing:*** Pipe earthing is the best form of earthing and is very cheap in cost.

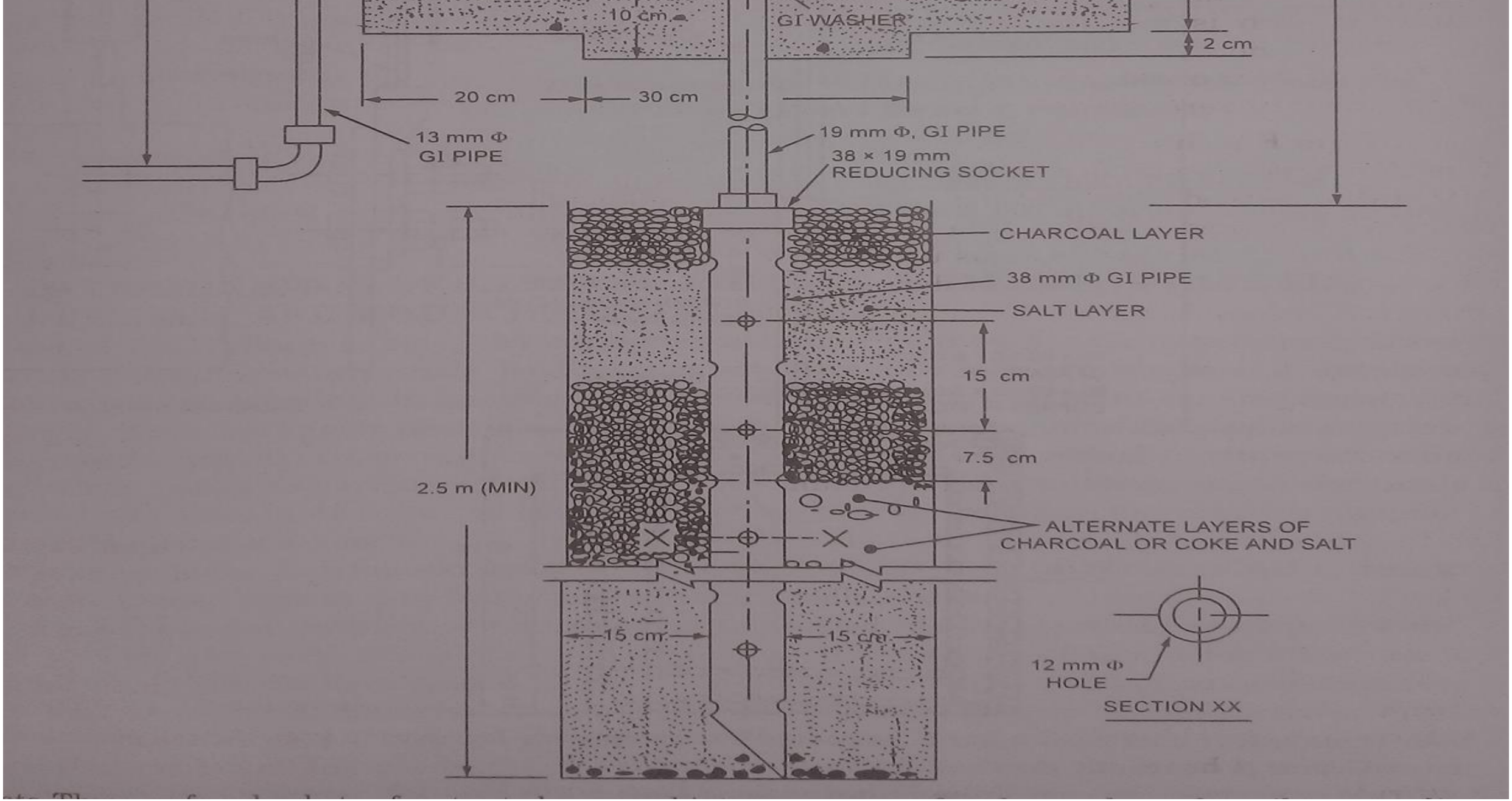
In this method of earthing, a galvanised and perforated pipe of approved length and diameter i placed up right in a permanently wet soil.

[Note:-Three or four buckets of water shall be pour into the sump through the watering chamber ever week.]

The pipe is provided with a tapered casing at the lower end in order to facilitate the driving. Th pipe at the bottom is surrounded by broken pieces of coke or charcoal for a distance of about 1 cm. around the pipe. Generally, alternate layers of coke and salts are used to increase th effective area of the earth and to decrease the earth resistance respectively. Another pipe of 1 mm diameter and minimum length 1.25 meters is connected at the top to G.I. pipe throug reducing socket.

In summer season the moisture in the soil decreases which causes increase in earth resistance So a cement concrete work is done in order to keep the water arrangement accessible. And i summer to have an effective earth, 3 or 4 buckets of water are put through the funnel connecte to 19-mm diameter pipe, which is further connected to G.I. pipe.

The earth wire (either G.I. wire or G.I. strip of sufficient cross-section to carry faulty curre safely) is carried in a G.I. pipe of diameter 12.7 mm. at a depth of about 60 cm. from the groun


10 cm
GI WASHER
2 cm
20 cm
30 cm
13 mm Φ
GI PIPE
19 mm Φ, GI PIPE
38 × 19 mm
REDUCING SOCKET
CHARCOAL LAYER
38 mm Φ GI PIPE
SALT LAYER
15 cm
7.5 cm
2.5 m (MIN)
ALTERNATE LAYERS OF
CHARCOAL OR COKE AND SALT
15 cm
15 cm
12 mm Φ
HOLE
SECTION XX

2.3 Method of earthing

4. ***Plate Earthing:*** An earthing plate either of copper of dimensions 60 cm x 60 cm x 3.15 mm of galvanised iron of dimensions 60 cm x 60 cm x 6.30 mm is buried into the ground with face vertical at a depth of not less than 3 meters from ground level. The earth plate is embedd in alternate layers or coke and salt for a minimum thickness of 15 cm. The earth wire (G.I. wi for G.I. plate earthing and copper wire for copper plate earthing) is securely bolted to an ear

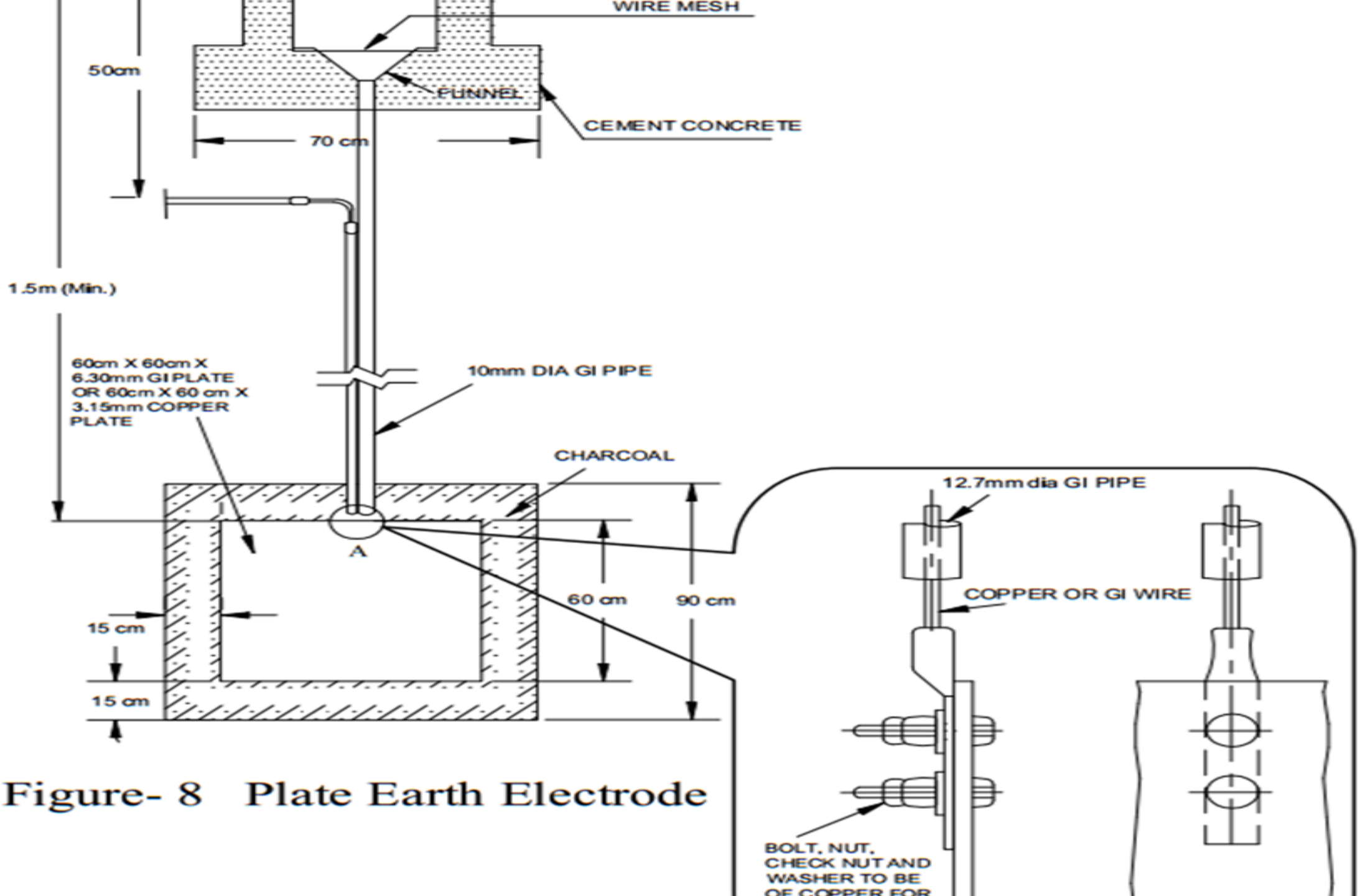


Figure- 8 Plate Earth Electrode

Selection of size of Earth electrode

5.1. For rod or pipe electrode following formula is used:

$$R = \frac{100\rho}{2\pi l}\log_e \frac{4l}{d} \quad \Omega$$

Where

ρ = Soil Resistivity Ohm-m

d = Diameter of rod or pipe in cm

l = Lenth of the rod or pipe in cm

Approximate value of the soil resistivity

Types of soil	Resistivity
1. Alluvium (Left by river or floods)	6-40
2. Alluvium dry sandy	60-200
3. Clay black soil	6-23
4. Sandy loam	6-14

5.2 For plate electrode following formula can be used

$$R = \frac{\rho}{4}\sqrt{\frac{\pi}{A}}$$

Where, A = Area of both sides of the plate (m^2)

2.4 Lightning Protection Scheme

- Electrostatic discharge of accumulated charge between clouds to clouds or cloud to earth which releases large amount of energy is known as lightning. Among whole lightning, 75% of lightning occurs between clouds and 25% lightning occurs from cloud to earth. To protect from lightning, lightning arrestors are used.
- During lightning, the system voltage becomes very high (kV or MV range), the lightning arrestors acts as closed switches or short circuits and large amount of charge is dissipated to the earth.
- At normal condition, the voltage level of the system is in the operating range and lightning arrestor acts as an open circuit. Therefore, there is discontinuity to the path of earth.

Lightning arrester (Surge Diverter)

- A lightning arrester is a device used on electrical power systems and telecommunications systems to protect the insulation and conductors of the system from damaging effect of lightning. The typical lightning arrester has a high-voltage terminal and a ground terminal. When a lightning surge (or switching surge, which is very similar) travels along the power line to the arrester, the current from the surge is diverted through the arrester, in most cases to earth.
- If protection fails or is absent, lightning that strikes the electrical system introduces thousands of kilovolts that may damage the transmission line and can also cause severe damage to transformer and to other electronic devices. Lightening produced extreme voltage spikes in incoming power line can damage the electrical home appliances.
- These equipment are connected between line and earth i.e. parallel with the equipment to be protected. They are made from metal oxide. The resistance of lightning arrester vary according to voltage level.

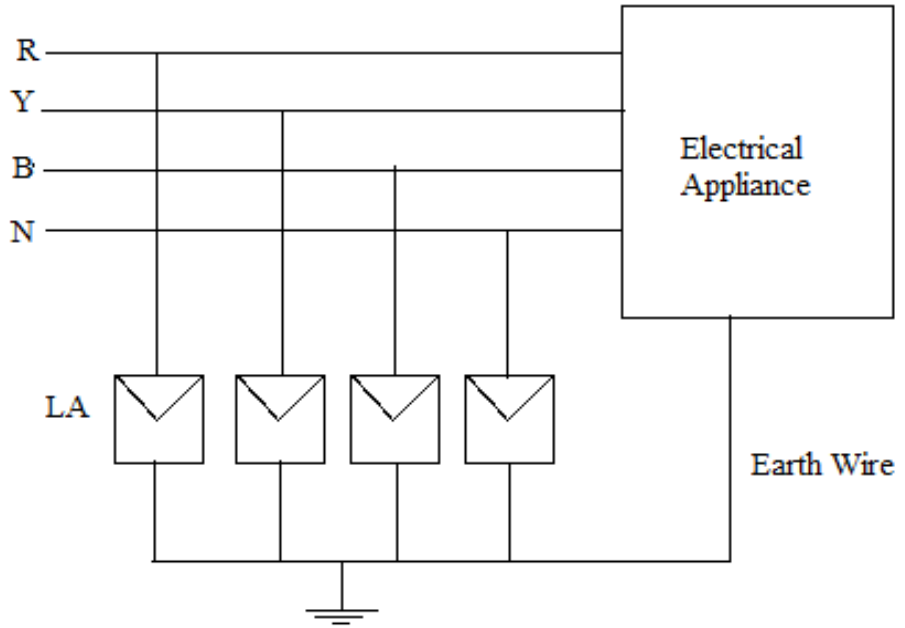
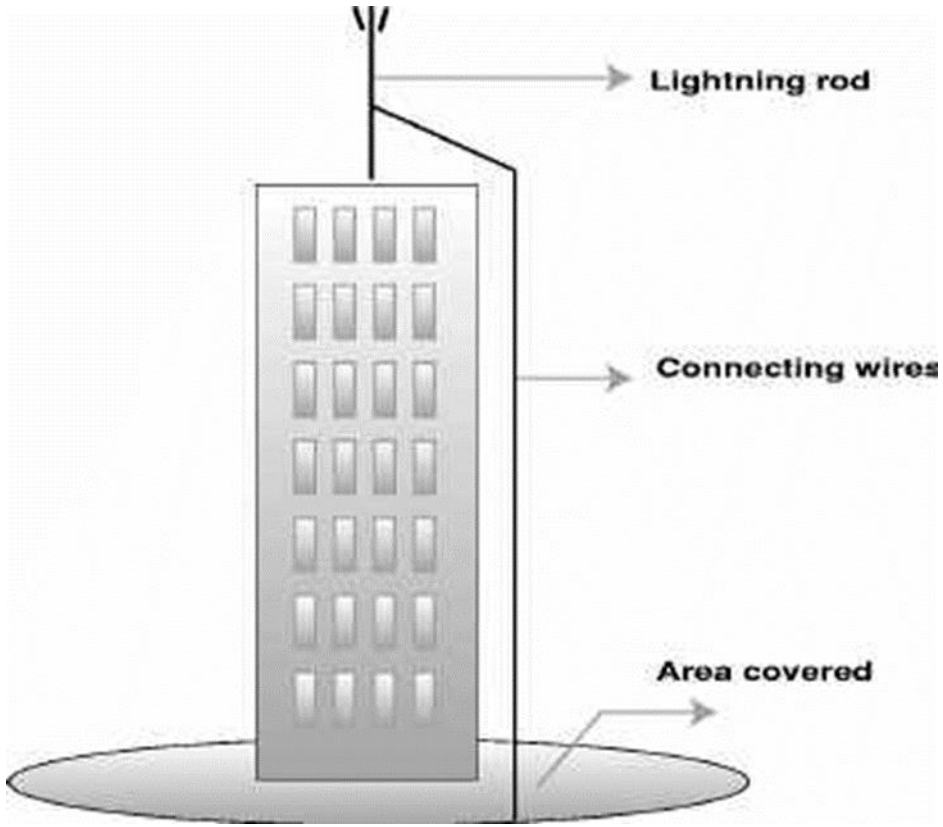


Fig. Lightning Protection Scheme


Lightning rod
Connecting wires
Area covered

Assignments

Write on followings

2.2.2 Factor affecting earth resistance

2.2.3 Method to reduce earth resistance