Lecture notes on

ELECTRICAL INSTALLATION AND ESTIMATING

A Course in 6th semester of diploma in ELECTRICAL ENGENEERING

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COURSE CONTENTS

1. INDIAN ELECTRICITY RULES

1.1 Definitions, Ampere, Apparatus, Accessible, Bare, cablew, circuit, circuit breaker, conductor voltage (low, medium, high, EH), live, dead, cut-out, conduit, system, danger, Installation, earthing system, span, volt, switch gear, etc. 1.2 General safety precautions, rule 29, 30, 31, 32, 33, 34, 35, 36, 40, 41, 43, 44, 45, 46. 1.3 General conditions relating to supply and use of energy : rule 47, 48, 49, 50, 51, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 70. 1.4 OH lines : Rule 74, 75, 76, 77, 78, 79, 80, 86, 87, 88, 89, 90, 91

2. ELECTRICAL INSTALLATIONS

2. 1 Electrical installations, domestics, industrial, Wiring System, Internal distribution of Electrical Energy. Methods of wiring, systems of wiring, wire and cable, conductor materials used in cables, insulating materials mechanical protection. Types of cables used in internal wiring, multi-stranded cables, voltage grinding of cables, general specifications of cables.

2. 2 ACCESSORIES: Main switch and distribution boards, conduits, conduit accessories and fittings, lighting accessories and fittings, fuses, important definitions, determination of size of fuse – wire, fuse units. Earthing conductor, earthing, IS specifications regarding earthing of electrical installations, points to be earthed. Determination of size of earth wire and earth plate for domestic and industrial installations. Material required for GI pipe earthing.

2. 3 LIGHTING SCHEME: Aspects of good lighting services. Types of lighting schemes, design of lighting schemes, factory lighting, public lighting installations, street lighting, general rules for wiring, determination of number of points (light, fan, socket, outlets), determination of total load, determination of Number of sub-circuits**.**

3. INTERNAL WIRING

3 . 1 Type of internal wiring, cleat wiring, CTS wiring, wooden casing capping, metal sheathed wiring, conduit wiring, their advantage and disadvantages comparison and applications. 3 . 2 Prepare one estimate of materials required for CTS wiring for small domestic installation of one room and one verandah within 25 m2 with given light, fan & plug points. 3 . 3 Prepare one estimate of materials required for conduit wiring for small domestic installation of one room and one verandha within 25 m2 with given light, fan & plug points. 3 . 4 Prepare one estimate of materials required for concealed wiring for domestic installation of two rooms and one latrine, bath, kitchen & verandah within 80m2 with given light, fan & plug points. 3 . 5 Prepare one estimate of materials required for erection of conduct wiring to a small workshop installation about 30m2 and load within 10 KW.

4. OVER HEAD INSTALLATION

4.1 Main components of overhead lines, line supports, factors Governing Height of pole, conductor materials, determination of size of conductor for overhead transmission line, cross arms, pole brackets and clamps, guys and stays, conductors configurations, spacing and clearances, span lengths, overhead line insulators, types of insulators, lighting arresters, danger plates, anti-climbing devices, bird guards, beads of jumpers, jumpers, tee-offs, guarding of overhead lines. 4.2 Prepare an estimate of materials required for LT distribution line within load of 100 KW maximum and standard spans involving calculation of the size of conductor (from conductor chart), current carrying capacity and voltage regulation consideration using ACSR. 4.3. Prepare an estimate of materials required for LT distribution line within load of 100 KW maximum and standard spans involving calculation of the size of conductor (from conductor chart), current carrying capacity and voltage regulation consideration using ACSR. 4.4 Prepare an estimate of materials required for HT distribution line (11 KV) within 2 km and load of 2000 KVA maximum and standard spans involving calculation of the size of conductor (from conductor chart), current carrying capacity and voltage regulation of the size of conductor (from conductor chart), current carrying capacity and voltage regulation consideration using ACSR

5. OVER HEAD SERVICE LINES

5.1 Components of service lines, service line (cables and conductors), bearer wire, lacing rod. Ariel fuse, service support, energy box and meters etc. 5.2 Prepare and estimate for providing single phase supply of load of 5 KW (light, fan, socket) to a single stored residential building. 5.3 Prepare and estimate for providing single phase supply load of 3KW to each floor of a double stored building having separate energy meter. 5.4 Prepare one estimate of materials required for service connection to a factory building with load within 15 KW using insulated wire. 5.5 Prepare one estimate of materials required for service connection to a factory building with load within 15 KW using bare conductor and insulated wire combined.

6. ESTIMATING FOR DISTRIBUTION SUBSTATION

6.1 Prepare one materials estimate for following types of transformer substations. 6.1.1 Pole mounted substation 6.1.2 Plinth Mounted substation

① General Principles of Estimating

Assessment of quantities of different items & their cost to plan the amount required for executing a work before actually carrying out the work.

Before tender; estimate is made out by a person called Estimator.

* Estimation for internal wiring

① Complete specification, ~~as~~ type of wiring to be adopted & quality of material to be used.

② Complete schedule of the points to be wired for with their switches & ~~sched~~ fittings.

③ Position of main switchgear & distribution board.

④ State of construction of building, the distance of the job from the main office, time available to complete the job.

* Characteristics of an Estimator

① Shld have ~~knowledge~~ a catalogues library & price list of all products of his own organization & associated items

1.2 page

② He shld keep continual attention to keep up to date prices & related info.

Electrical schedule

It is the list or plan of building which provides us the info regarding the number of points, in each room of a building under estimation.

Catalogues

Any list of items details which helps the estimator save time by making judicious decision useful for his work.

Good estimating knowledge

With update knowledge of

1. Availability of product
2. Source of production & vendor selection.
3. New product & their quality.
4. Price of product & discount

Contingencies

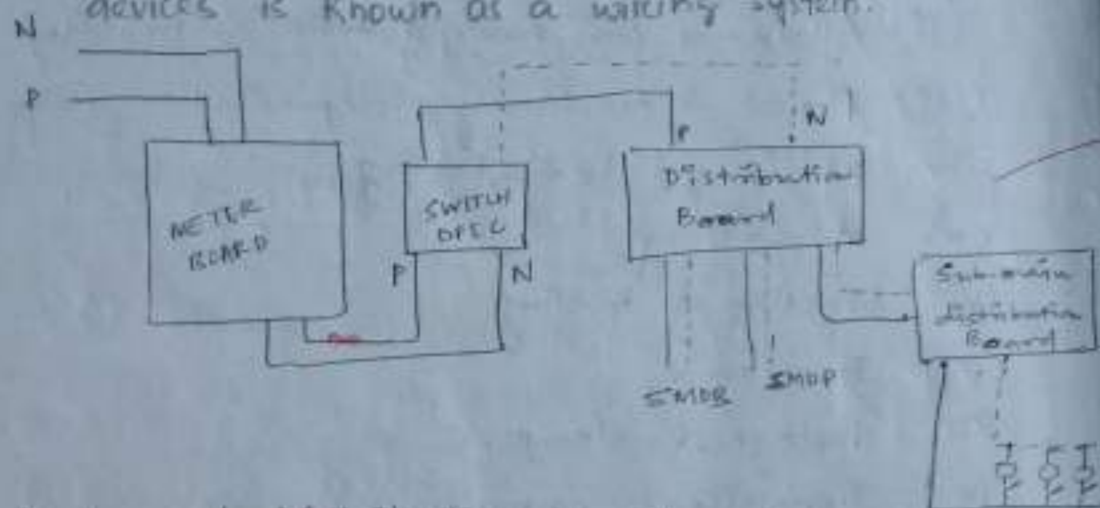
This amount is provided to cover the unforeseen expenditure such as extra cost on account of delay in delivery, minor accident & unexpected variation from the plan of estimating department

Expressed as % of total cost (labour + material)

→ Additional expenses compensated by contingencies during natural calamities

Wiring System

→ A n/w of wires connecting various accessories for distribution of EE energy
(19) from supplier meter board to ~~...~~ numerous electrical consuming devices such as lamp, fan ~~& other~~ etc., through controlling & safety devices is known as a wiring system.



Internal Distribution of Electrical Energy

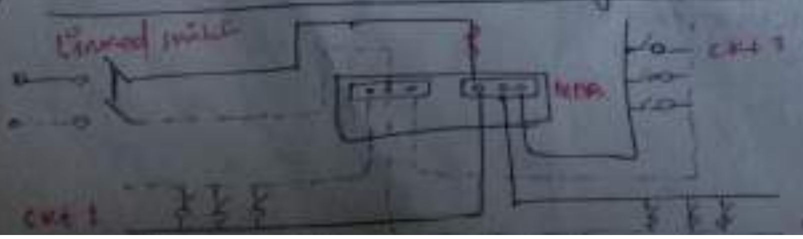
As per Indian Standard

(i) Maximum number of points of light, fan, 5A socket in one circuit can be 10.

(ii) Maximum load can be connected in 800 W.

(iii) In case of more Load ~~&~~ or power are required; then it is to be done by having ~~one~~ more than one circuit.

(A) Distribution board system



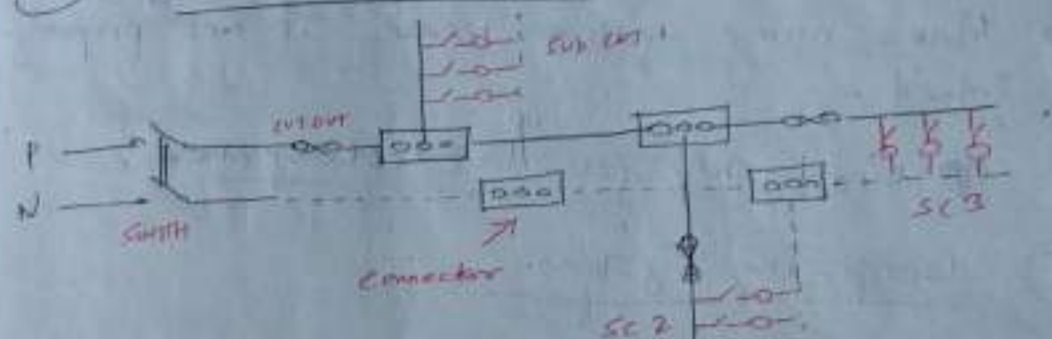
MDB - Main distribution board.

In large buildings

* If one main distribution board is used, then loads would be in large distance as a results large voltage drop happes.

* To avoid such recurrance, sub-distribution board is conected to MDB. SMDB installed near the load.

(B) Tree system

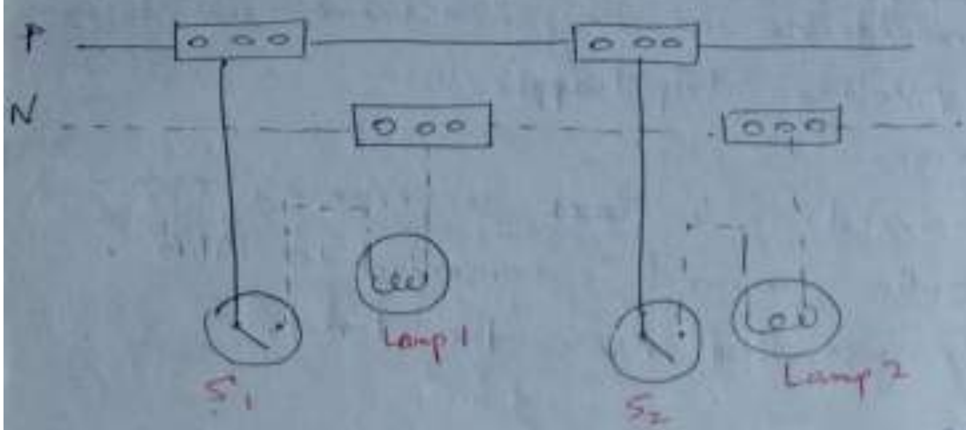


→ Earlier days such system were adopted. Due to following drawbacks, obsolate system.

(i) Voltage across all lamps not same. Last branch has least voltage due to drop.
(ii) Fuses are scattered.
(iii) Number of joints are involved in circuits.
(iv) In case of fault all joints have to be located.

METHODS OF WIRING

(I) Joint Box or Tee system

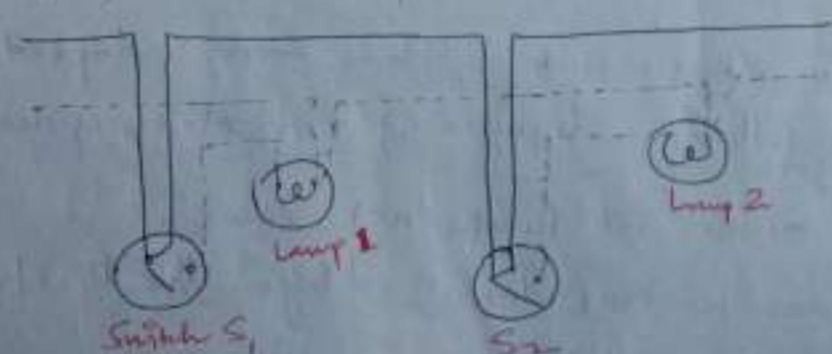


→ Saving cable/wire but extra cost of joints boxes ~~boxes required~~.

→ Make wiring system weak if not properly joined.

→ Used only for "low cost system".

(II) Loop-in System



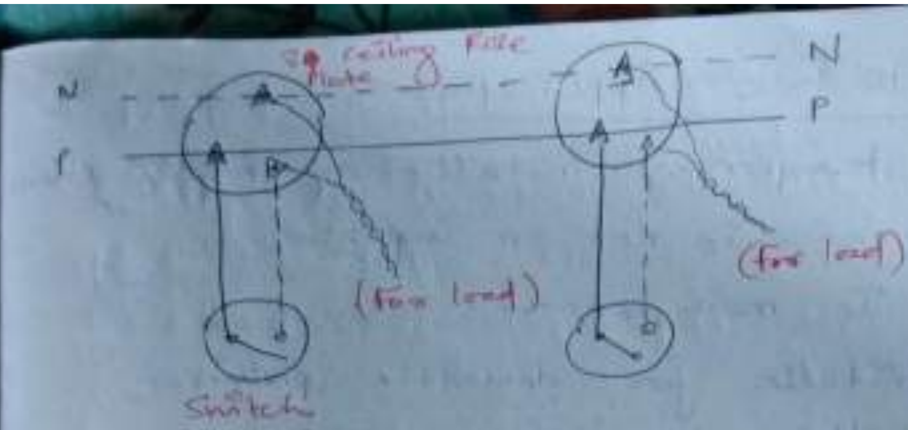
* ~~Dis~~ Advantages -

(i) Joint box are not required.

(ii) Fault Location is easy; as no joints are concealed beneath floors or in roof space.

* Disadvantages -

(i) length of wire is more, Voltage drop ↑.

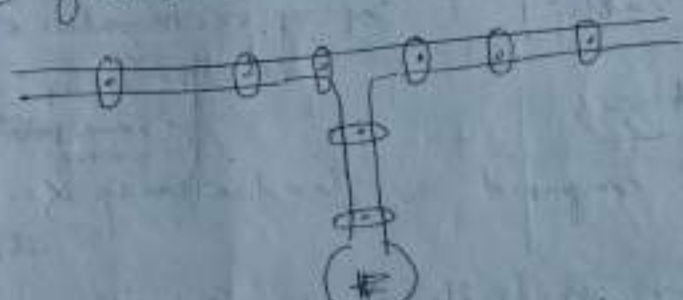


* SYSTEMS OF WIRING -

→ 6mm above the wall, wire is held.
→ Screw 38mm
→ Interval 30 cm - Location of cleat

(I) Cleat Wiring

Two grooves Three grooves.



→ For VIR (Vulcanized Indian Rubber) & PVC (Polyvinyl chloride) Cables.

→ Made up of porcelain.

Advantages

(1) Cheapest (2) Installation & dismantling is easy & Quick.

(3) Material is recoverable after dismantling

(4) Inspection can be made quickly.

Disadvantage

(1) Not good looking; (2) ~~Time poor~~ Less durable.

Where to use / Application

1. For temporary installation in dry places
2. Appearance is not so imp.
3. Cost is main concern
4. Not suitable for domestic premises.
5. Low voltage < (250 Volt)

(II) Wooden casing & capping wiring –

→ V groove
→ Capping is screwed to the casing at 15 cm [illegible]
→ 1.2 cm above the wall casing is fixed

[Groove for cable] [Cap of rectangular shape]

→ To keep it dry
→ Same polarity in one groove

*** Advantages**

(i) Cheap compared to lead sheath & conduit wiring.

(ii) Easy to install & rewire.

(iii) Good insulation for conductor, as they are wide apart

~~(iv) Moisture proof.~~

(v) Easy to inspect.

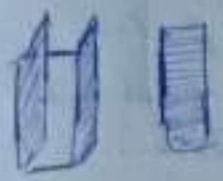
Disadvantages

(i) Risk for fire hazard..

(ii) Labour cost is higher.

(iii) Used on surface & cannot be conceal. in plaster

Due to ~~a~~ large cost of teak wood; PVC casing & capping is being used.



(III) CBTS or TRS wiring

CBTS → Cab Tyre Sheathed

TRS → Tough Rubber Sheathed

→ 1, 2, 3 core cable are used.

→ chemical, steam, water proof but slightly affected by lubricating oil.

→ Batten width is depend upon the nos of conductor it carries; (Table 2.2)

⇒ at least 10mm

→ Batten is fixed on wall with SCREW at an interval of 75cm

⇒ Brass ~~pin~~ clip are provided ~~10cm~~ at interval of 10cm horizontally 15 cm in Vertical runs.

Advantages

(i) Installation easy & Quick.

(ii) Life is long.

(iii) Within certain limit it is fire proof.

(iv)

Disadvantages

(i) Good workmanship is required for TRS.
(ii) For open outdoor wire prone to sun & rain such scheme is not recommended as it may depreciate insulation.

* Application

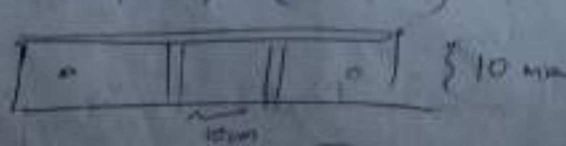
→ Low voltage app
→ for lighting purpose.
→ Can't be used in damp place & workshop as it may get mechanically injured.

(IV) Lead Sheathed / Metal Sheathed Wiring

Insulated wires, TRS or PVC with an outer covering of sheath of lead-aluminium alloy containing abt 95 % lead.
→ It provides mechanical protection & protect against dampness & atmospheric corrosion.

→ The lead covering is electrically continuous & connected to the earth at the point of entry.

→ Placed on wooden batten; well varnished. > (10mm)



* Advantages

(1) Mechanical protect from injury.
(2) Easy fix
(3) Damp & corrosion protect
(4) Can be used in rain & sun exposed area.

Disadvantages

(1) Costlier than TRS.
(2) Chemical corrosion may occur.
(3) In case of damaged insulation, it may give shock
(4) Skilled labour & proper supervision is required.

(V) Conduit Wiring.

-> Initially steel conduit were used but nowdays PVC conduit are employed.

-> Cheap cost, labour time save, Light weight,

-> Resistant to Acid, Alkali, Oil & moisture.

-> Can be buried in lime or cement without ill effects.

-> ~~Also~~ PVC not suitable for location prone to fire hazard.

-> Size 12mm, 16, 19, ~~+ 6mm~~ 25mm, 31mm, 38 mm 50 mm.

Advantage

(1) Mechanical & Fire hazard protection
(2) Water proof, (3) Easy maintenance

Disadvantages

(i) costly

(ii) It's erection ~~is~~ requires time.

(iii) Experienced & high skilled labour required for ~~job~~ carrying out the job.

Application

(i) Where considerable dust is present such as textile mills, sawmills, flour mills.

(ii) Damp situation

(iii) Residential & Public buildings.

(iv) Places where documents are kept such as record room.

* CHOICE OF WIRING SYSTEM

(i) Safety

(ii) Durability – Time of Lasting.

(iii) Appearance

(iv) Mechanical protection

(v) Permanency

(vi) Accessibility

(vii) Initial cost

(viii) Maintenance cost.

Wiring Materials & Accessories

WIRE	CABLE
① Single wire may be bared or covered with insulation. 	① Multiple wires covered with insulation 

** Cable consist of three parts

(i) Conductor / Core :- Metal strand

(ii) Insulator / dielectric :- Avoid leakage current.

(iii) Protective covering :- From mechanical damage

\+ CONDUCTOR MATERIAL USED ~~for~~ ~~AL~~

Aluminium	Copper
(i) Cheaper	(i) Costlier
(ii) Conductivity low (60%) of copper	(ii) Conductivity ↑↑
(iii) $\rho = 2.87 \times 10^{-8}\ \Omega\text{-m}$ ($R = \rho l/A$) @ 20°C	(iii) $\rho = 1.786 \times 10^{-8}\ \Omega\text{-m}$
(iv) Used in distribution system. ACSR.	(iv) Mechanically strong hard, ~~long~~ durable ductile
(v) ~~Heats wiring~~ High resistance,	(v) Resistive to oxidat[ion] corrosion, pitting.
(vi) Not easily solderable	(vi) Withstand dampness

INSULATING MATERIAL

To prevent leakage current from the conductor.

It should be highly resistive to the flow of electric current through it.

Properties :

(i) High ρ
(ii) High flexibility
(iii) ↑↑ dielectric strength
(iv) Non-inflammability
(v) Non-hygroscopic (Non retaining water)
(vi) Resistive to moisture, acid & alkali.
(vii) Resistive to high temperature without much deterioration.

Type

① RUBBER :

Ability of storing electrical energy in an field (external)

- Relative permittivity $\cong$ 2 to 3.
- Dielectric strength = 30 KV/mm.
- Absorb moisture, may swell when heated with 60°C or 70°C.

② VULCANIZED INDIA RUBBER (VIR)

→ Does not absorb moisture, water-proof
→ Sulphur content – attack copper.
→ To avoid the above; a pure rubber is
... on the conductor. or the copper

Air 3kV/mm

③ Impregnated paper

→ Cheap, low capacitance
→ High dielectric strength (30 KV/mm)
→ High insulation resistivity (10^{15} Ω-cm)
Ad → Can withstand high temperature without deterioration.

Dis → hygroscopic - moisture absorber.

④ Polyvinyl chloride (PVC)

→ Synthetic compound.
→ Preferred over VIR in extreme condition.
→ Mechanical properties is worse than Rubber (elasticity & recovery from stretching).
→ low cost; As a result widely used.

⑤ Silk & cotton

→ Used in low voltage cable
→ Used for instruments & motor wiring.

MECHANICAL PROTECTION

→ All insulating material are mechanically weak.
→ Mainly used in ~~cable cable~~ underground cable

... steel tape are provided

* Type of cables -

Wire are divided According to

(i) Conductor used ; (ii) Number of cores ;
(iii) Voltage grading ; (iv) Type of insulation.

→ Copper
→ Aluminium

250/440 V
650/1100 V

Single core
two
three

Vulcanized Indian Rubber ↔ Tough rubber Sheath (TRS)

Lead Sheathed cables ↔ PVC cable

Weatherproof cables ↔ Flexible cord & cable

XLPE cable
[Cross-linked polyethylene]

① Vulcanized Indian Rubber :- Cable -

→ 240/415 Volt ; 650/1100 Volt.

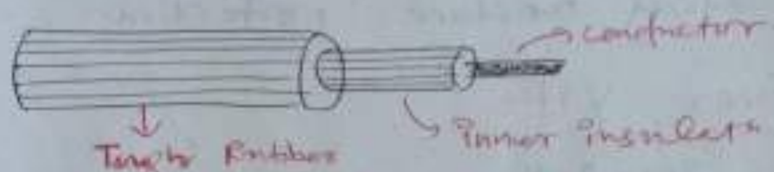
→ Thickness of rubber insulat^n ∝ Voltage grading.

→ Copper wire is TINNED (coated with TIN) to provide protect^n against sulphur, ZnO in VIR.

→ Bitumen wax is provided on the rubber for moisture proof.

② Tough Rubber Sheathed (TRS) Cable

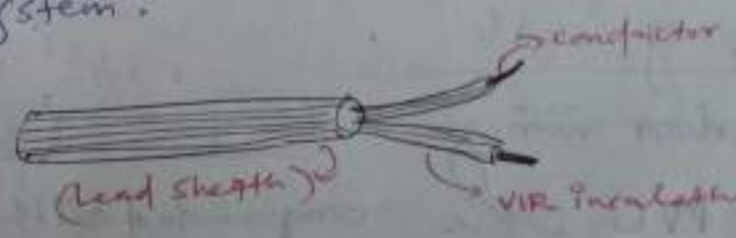
→ 250/440V & 650/1100 Volt grade
→ Used in TRS wiring.
→ Same as VIR but provided with additional insulation & protection against tear & wear.
→ Waterproof.



→ 1 core, 2 core, 3 core cables available.
⊗ → cheap cost & lighter weight than ~~lead-al~~ ~~the~~ lead-alloy sheathed cable.

③ Lead Sheathed cable

→ 240/440 Volt grade.
→ lead sheathed cable : cover with continuous sheath of lead.
→ Protect against moisture, mechanical injury.
→ Can be used ~~in~~ without casing & conduit system.
→



(4) PVC (Polyvinyl Chloride) Insulated cable

→ can be used in casing-capping, batten & conduit wiring system.

→ PVC is harder than rubber ; doesnot required cotton taping & braiding for it's mechanical & moisture protection.

PVC over VIR

(i) better insulation
(ii) better flexibility
(iii) No chemical effect on conductor.
(iv) Thin layer of PVC required for insulation.
(v) Small diameter cable ; size ↓.

Disadvantages

Insulation Resistance < VIR.
(but negligible under 600 V)

→ So, used frequently.

(5) Water proof cable

→ for outdoor wiring.

→ VIR or PVC cable compounded with Wheather proof Insulation.

(17)

(6) Flexible cord & cables

→ Wire silk/cotton/plastic covered.

→ It has tinned copper conductor; covered with plastic (for diff colour).

→ Flexibility & strength obtained from number of strands of wires.

X → Flexibility allow consumer to have mobility

→ Must not be used in fixed wiring.

→ Used for Household application

(7) XLPE cables

→ insulatn made of polymers.

→ The mechanical property of polymer ~~depends~~

eg. [Tensile strength, elongation elasticity & resistance against cold] depends upon chemical structure.

Advantages of XLPE over others

(i) High current rating

(ii) ↑↑ SC current rating

(iii) Longer service life

(iv) 130°C temp withstand for short time

(v) Low dielectric loss.

(vi) Excellent mechanical features improve protectn against external effects.

(vii) Resistant to; acid, alkali .

MULTI STRAND CABLE

It has following advantage compared to single strand cable.

* Withstand incredible amount of vibration without breaking.

(i) More flexible & durable

(ii) Handled conveniently

(iii) Surface area is more; so heat radiating capacity is better.

(iv) Skin effect is better as conductors are tubular; especially in high frequency.

3, 7, 19, 37, 61, 91 → To obtain circular contour.
Number of strand

→ Each layer has '6' strands more than the layer beneath ~~layer~~ it.

→ Alternative layers are spiralled in opposite direction To prevent "BIRD AGING" when the conductor is bent.

→ 2% additional wire is required for spiralling.

→ Actual cross-section is 2% more

* Size of cable

(i) 3/20 → Number of strand; 20 → Gauge number of each strand (SWG)

(ii) $19/1.12\,mm$ → strands
→ diameter of each

(iii) $19.35\,mm^2$ → Total cs area of cable for $19/1.12\,mm$ cable

Skin depth $(\delta) \simeq 503\sqrt{\frac{\rho}{\mu_r f}}$ ρ → resistivity, f → frequency, μ_r → relative magtic permeability

SWG = Standard wire gauge

Gauge → wire diameter.

$LI = N\Phi$

$L = \frac{IN^2A}{l}$

* General Specification of cable –

(i) Size of cable in metric system.

Eg – $19/2.24\,mm$ (Number of strands & diameter of each strand in mm)

(ii) Type of conductor used (Al / Cu)

(iii) Numbers of core (1, 2 or 3).

(iv) Voltage grade (250/440 V or 650/1100 V).

(v) Type of cable with general ~~specification~~ description regarding insulation, shielding, armouring, braiding &, etc.

Ex

7/1.2, Al, flat twin core, 650/1100V,

* Disadvantages of stranded Conductor

(i) Large diameter for same current carrying capacity as solid cable.

(ii) Expensive

(iii) Complex manufacturing

(iv) Prone to corrossion.

* SOLID Conductor

Adv

-> Cheaper
-> Durable
-> Simple
-> Small diameter
-> Not prone to corrosion

Disadv

-> No flexibility
-> Small diameter are sold.
-> At constant vibration; the cable tear/break.

Accessories

~~MAM~~ MAIN SWITCH & DISTRIBUTION BOARD

* IER-50: a linked switch (which operate simultaneously on both phase & neutral wire) to be provided just after meter board.

* Suitable cut out to be provided just after the linked switch. (protect against over current)

For 1ϕ, 2wire : DPIC (Double pole Iron clad)

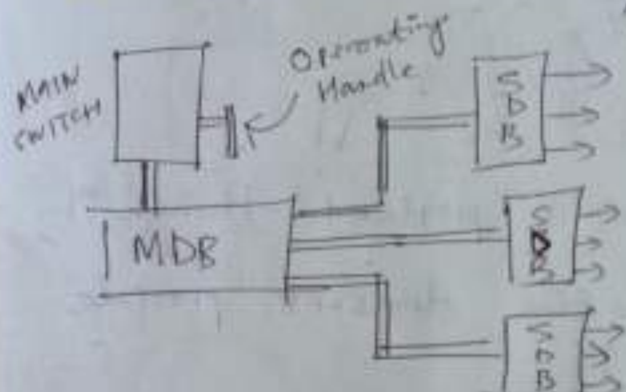
For 3ϕ, 3wire : TPIC (three pole Iron clad)

* IE Rule : 32

No fuse on neutral wire.

* Distribution board :

It is an assembly of parts ; including one or more fuses / CB, arranged for distribution of ~~the~~ electrical energy from ~~the~~ MDB to circuits/SDB.



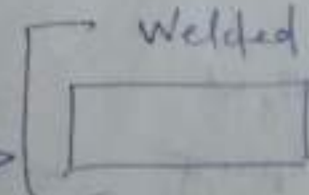
* CONDUIT

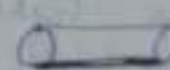
(1) Light gauge steel - plain conduit
(2) Heavy gauge steel - screwed
(3) Flexible conduit
(4) PVC conduit.

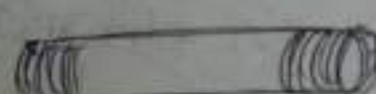
Quick installation
Cheap,

Welded at

Closed joint conduit







Costly, tough, permanently installation

→ Threaded @ two end.
→ For Joint

(3) Flexible Steel Conduit

→ light gauged galvanized steel strips spirally wound & to some extend, interlock so as to form a tube.

→ Upto 250 m long conduit available.

→ So; no interlocking is required.
(Hence; No threading)
No elbow is required.

→ A neutral wire is provided through it; as, spiral formation doesnot provide efficient continuity.

→ Efficient in case of vibration.

→ Costly.

(4) PVC

→ light weight
→ Water proof → No chemical sensitivity.
→ Corrosion proof
→ Insulation (high dielectric strength).
* Threaded type or plain type

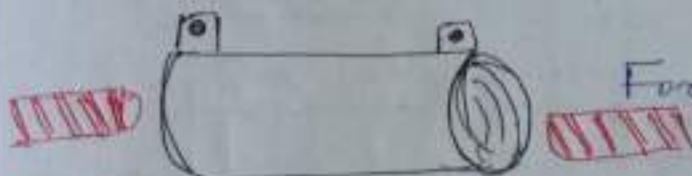
Disadvantage

→ Separate earth wire need to be run.

* conduit accessories & fittings:

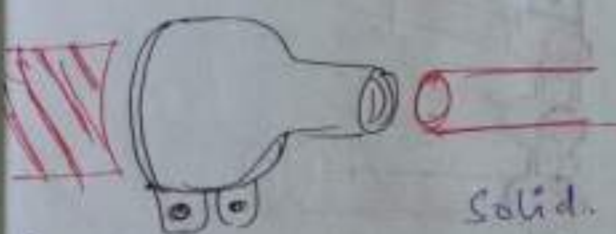
(1) Conduit coupler

for rigid conduit



For flexible conduit

[Grip coupler]

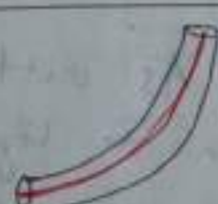


Solid.

flexible

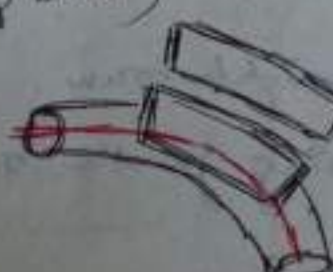
(2) Bends, Elbows & Tees

(Sharp bend)



(Normal Bend)

ELBOW
→ Short radius
→ Sharp turn area.
→ Neat wiring
→ Inspection can be done



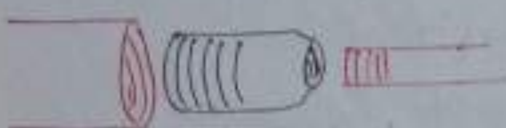
(Inspection ~~bend~~ Elbow)

(Solid tee)

(3) Conduit bushing —

Male Female

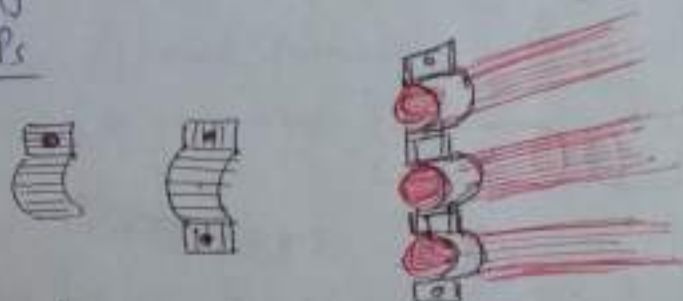
(4) Conduit Reducer



(5) Fixing of Conduit

fixing conduit with minimal damage to the wall.

Clips



(6) lock Nuts.

(7) Conduit Boxes

Purpose (i) As outlet box for providing connection to light, fan.

(ii) For pulling cable into the conduit. (inspection boxes)
At 30 meters in straight run.

(iii) Junction box. Housing junction of cable.

Side entry Back entry

* LIGHTING ACCESSORIES

1. Switches
2. Ceiling Rose
3. Socket outlet
4. Plugs
5. Lamp holder

1 Switch

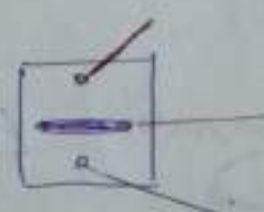
(a) One way switch

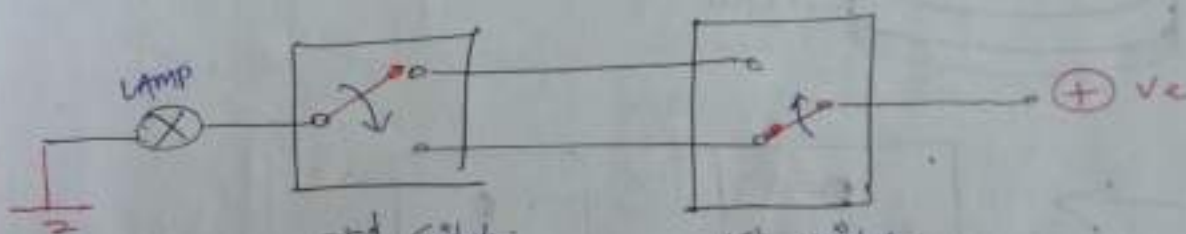
240V, 5-6 A

(b) Two way switch

Stair case

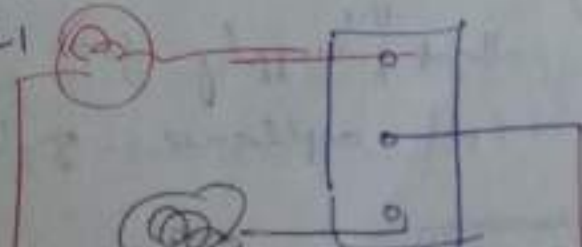
Three / Four Terminals





(c) Two way centre off

Centre off



(d) Double pole main switches

DPIC switch.

Combination of two one-way switch ~~in~~ which can be operated simultaneously as the ON-OFF terminals.

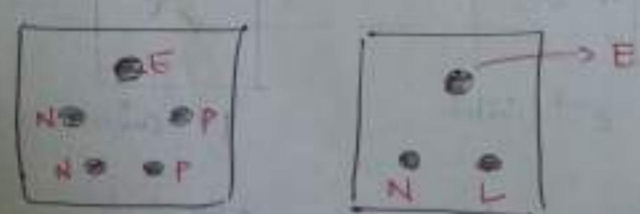
(e) Push button switch

Controlling electric bell.

(f) Table lamp switch

(2) Ceiling Rose

(3) Socket Outlets

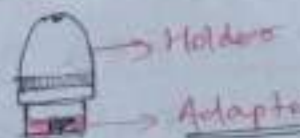


(4) Plug

It collect the supply from the socket outlet to electrical appliance. eg. lamp, fan, heater.

[3 pin plug]

(5) Lamp holder



(To make suitable) (modify)

Mobile charger
(AC/DC adapter)

FUSEs

→ Carry normal current safely
→ To break ckt for overcurrent (heating)

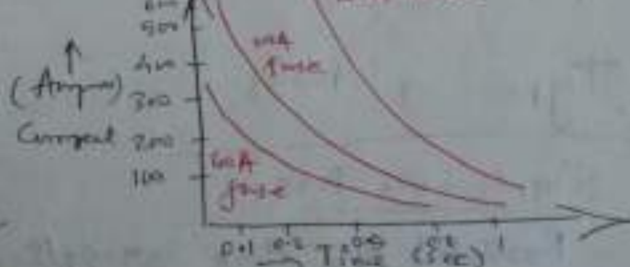
It is the cheapest element that protect the electrical circuit under SC, excessive over load, fault.

Used for
→ Overload & short ckt protection upto 66 kV (HV) & 400V (in LV)

ACTION

→ Excessive current flow → heating → melt the fuse wire → disconnect (BREAK) the circuit from supply → Protect devices

→ The TIME of blowing of fuse depends upon magnitude of excess current



* Advantage

(i) Cheapest protection
(ii) No maintenance
(iii) Automatic
(iv) Range of operation high without Noise, flame, gas or smoke
(v) Small size (vi) Inverse time c/c.

* Disadvantage

(i) Rewiring/replacement take time

Characteristics of Fuse element

1. Low melting point
2. Low ohmic loss
3. High conductivity
4. Low cost
5. Free from deterioration due to oxidation.

Eg :- # Lead (37%) Tin (63%) - Upto 15A
(∵ for I>15A ; diameter would be larger).

* Copper tinned outside for I>15A
(Save from oxidation).

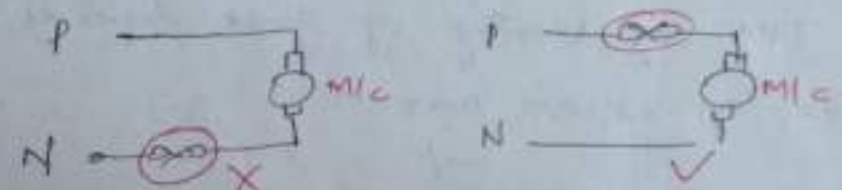
* Zinc used for delay operation. [not melt quickly for small overload]

* Silver is used inspite of having high cost

* Fuses are provided on live not neutral

→ To facilitate maintenance to the m/c or system without shock.

→ If fuse is provided on the neutral, then the m/c is still in connection with the supply



* Types of Fuses

1. Supply main Fuse -

Provided by the supplier & is placed just after meter & sealed by him.

Only authorised person would open & replace the fuse if it is blown out.

2. Consumer main fuse -

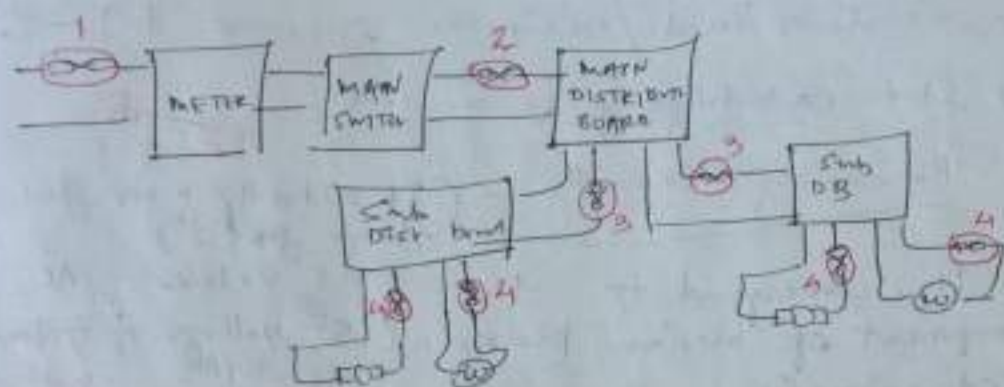
Placed just after main switch [illegible]

(3) Sub-circuit fuse -

A wiring system is divided into a number of sub-circuits & each are provided with a fuse.

(4) Point fuse

In quality indoor wiring of building, each component gets a fuse of its own.



* Important Defination

(1) Fuse - that break system (3) Fuse line - which need replacement

(2) Fuse wire - melting part

(4) Current Rating - Specified by manufacturer. (RMS value of current a wire can carry without deterioration)

(5) Fusing Current

→ Minimum current at which element melt.

→ More than "Current rating".

$$\boxed{I_f = K d^{3/2}}$$

K → Fuse constant

depends upon

(a) Type of material used

(b) X-section area

(c) Type of enclosure.

(d) Type of surface.

⑥ **Fusing factor** – Current Rating < fusing Curt < Breaking Capacity

$$F_f = \frac{\text{Minimum fusing current}}{\text{Current Rating of fusing element.}} > 1$$

→ For less F_f ; it is prone to malfunction due to "action in overload for small time" which might not be dangerous.

→ Semi-enclosed / rewirable fuse = 1.9 – 2.0

→ Std catridge fuse = 1.45 

⑦ **Breaking Capacity** – (It actually never flow through fuse.)

It correspond to the RMS value of AC component of maximum current & voltage of system.

* **Determination of Size of FUSE-WIRE** – without physically breaking / melting

factors

ⓐ Maximum current rating of the Circuit
ⓑ Current rating of the smallest cable in ckt to be protected by fuse.

* → "fuse" is the weak link in a circuit.

→ If a small appliance is connected to a SDB (Sub-distribution board) with comparably large fuse ; then a local fuse to be provided for that appliance.

→ In a ckt where current is fluctuating, fuse wire is choosen such that it can carry momentary overload (g-motor)

→ For higher size cable (to minimize the

→ For normal lighting ckt;

Current rating of fuse = 3A

Minimum fusing current = 5A

(∵ Cable can carry 5A).

$\therefore$ Fusing factor $= \frac{5}{3} = \underline{1.67}$.

SWG (standard wire gauge)	Diameter (mm)	Current Rating	Fusing curr (A)
40	0.122	1.5 A	3
35	0.213	5 A	8
30	0.315	8.5A	13
20	0.914	34A	70
15	1.827	78	197

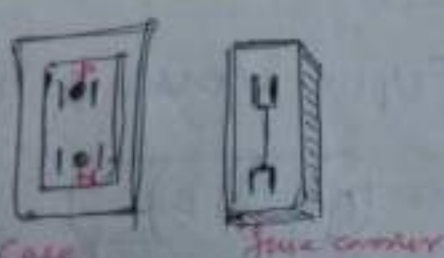
Fuse Unit

(1) Round type FU

→ Porcelain/Bakelite box

(2) Kit-kat type

→ Semi enclosed wireable fuse



→ fusing current = 2 Rating current

→ Std rating of fuse wire are: 6, 16, 32,

* Disadvantages of Kit-kat type fuse

(1) Unreliable operation
- Possibility of ~~renewable~~ renewal by fuse wire of wrong size.
- Due to oxidation the fuse wire deteriorate.
- Length of wire varies results in alteration of rating.

(2) Lack of discrimination

A 50A fuse can't be discriminated from a 40A fuse but 80A fuse ; (diameter of wire used)

(3) Small time lag

(4) Low capacity of breaking

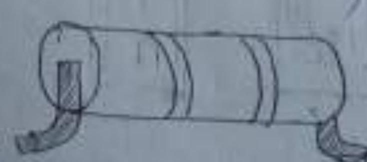
(5) No-current limiting features

(6) Slow speed of operation

No mean of extinguishing the ARC that blows after fuse melt.

(3) Catridge type (Upto 600 Volt & 800A)

→ Enclosed type fuse.



→ Glass covered filled with powder, sand, $CaCO_3$, quartz (FILLER).

→ filler cool down the arc & quench it.

(4) HRC fuse

→ High Rupturing capacity

→ At generation station, High rating ~~fuse~~ current leads to high stress.

→ Rewirable fuse is not advisable. So, HRC 500 MVA upto 66 KV & above

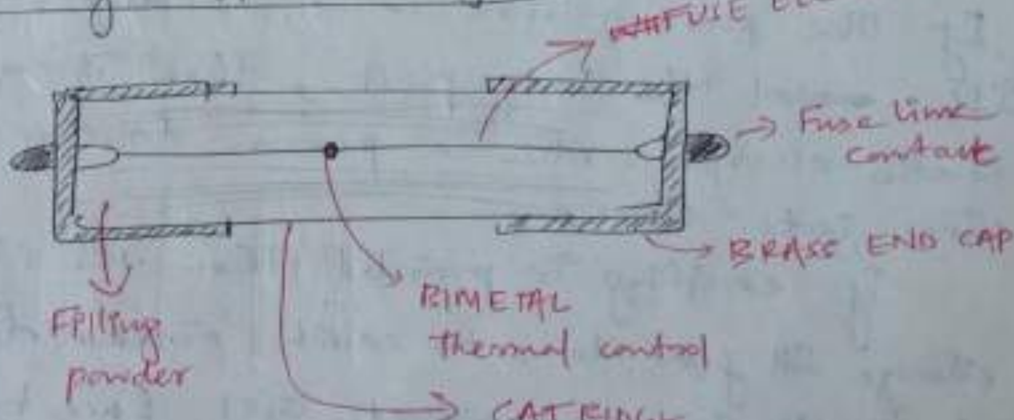
Advantages

1. No maintenance.
2. Quick operation & reliable
3. Do not deteriorate with time
4. Inverse - Time current C^s.
5. Capable of clearing high & low current

(8) Disadvantages

1. One time use
2. Interlocking is not possible

Catridge type HRC fuse



(a) Pre-Arcing : melting of Silver elements

(b) Arcing operation : vaporization of elements

EARTHING

→ Connection of neutral point of a supply system / non-current carrying parts of electrical apparatus [metallic covering, covering of cable, earth terminal of socket outlet] to the general mass of Earth in such a manner that at all time immediate discharge of EE energy takes place without danger.

* Objective (उद्देश्य)

① No potential of current carrying conductor shall be ~~same~~ ~~to a potential~~ equal to earth other than insulation.

✓ ② To avoid electric shock to human beings

✓ ③ To avoid risk of fire due to Earth leakage current through unwanted path

* If live part of wire comes in direct contact with ~~metal~~ M/C body part, then it accumulate static charge. When a person touches the wire gets shocks.

If earthing is provided then the static charge will flow down to earth without danger & if ~~it~~ I exceed safety limit fuse break.

Earthing	Grounding
→ Dead part which does not carry current under	→ Connecting the part which carry current under

* IS Specification Regarding Earthing of Electrical Installation (39)

(i) Distance of Earth from building :-

An earthing electrode shall not be situated within '1.5 m' dist from the building. (Away atleast 1.5mtr) ??

(ii) Size of Earth continuity conductor :- (ECC)

CS (cross-section) of ECC $\geq$ 2.9 mm^2 (14 SWG)

OR

~~Half the~~ ECC $\geq$ half the installation conductor size.

(iii) Resistance of Earth :-

- Must be low enough to make RELAY operate on earth fault.
- It changes with ~~weather~~ weather (moisture of soil)
- No hard & fast rule for "R".

Large PS — 0.5 Ω

Major PS — 1.0 Ω

Small SS — 2.0 Ω

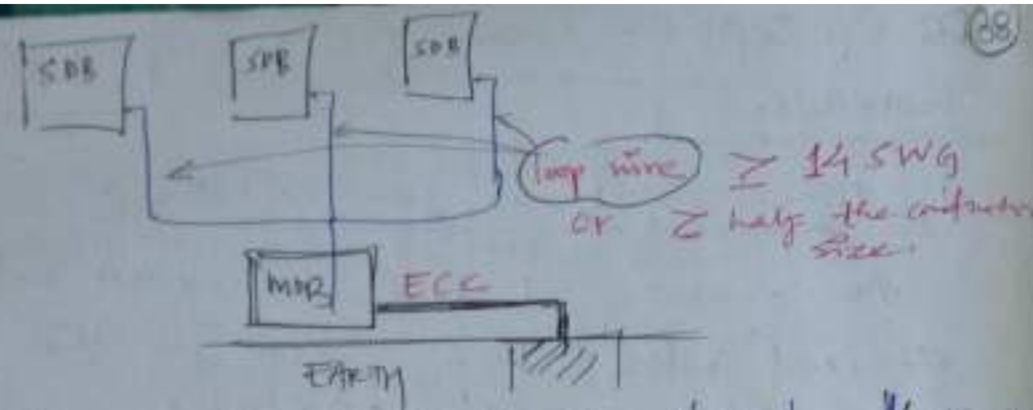
Other case — 5.0 Ω

ECC from Electrode to M/c — 1.0 Ω ?

(iv) The earth wire & electrode will have same size.

(v) G.I. (Galvanised pipe) pipe of 130 mm diameter hold/carry ECC

(vi)



(vii) The earth electrode is placed vertically such that it touches all the layers of earth. ?

* Point to be EARTHED :-

(i) Earth point of 5-pin & 3 pin power plug socket.

(ii) All metal covering/casing containing any electric supply line/apparatus.

(iii) Metal casing of portable apparatus such as heater, soldering iron, drills.

(iv) Casing of all generator, motor, tf.

(v) The neutral conductor of 3φ, 4W system shall be earth ~~at~~ along the distribution line or at some specific location.

(vi) Supply lines having ~~earth~~ concentric cables, the external conductor should be ~~ea~~ earthed ~~by it~~

(vii) For DC 3-wire system, middle wire is earthed at the generating station.

(viii) Pylon - steel tower carrying Tns line.
At every 1.61 km (mile)

(ix) ...

(#) Factor influencing Earth resistance

(1) Condition of soil
   (a) Temperature of soil
   (b) Moisture of soil
(2) Size & spacing of earth electrode
(3) Depth at which electrode is placed.
(4) Material of conductor
(5) Quality of coal dust & charcoal in the earth electrode pit.

(#) Methods of reducing earth resistance of the system —

(1) Removing rust from the electrode/plate/pipe.
(2) In summer season, wetting/soaking charcoal bed with salt water.
(3) Increase plate area
(4) Inc. pit depth.
(5) Inc. number of parallel electrodes.

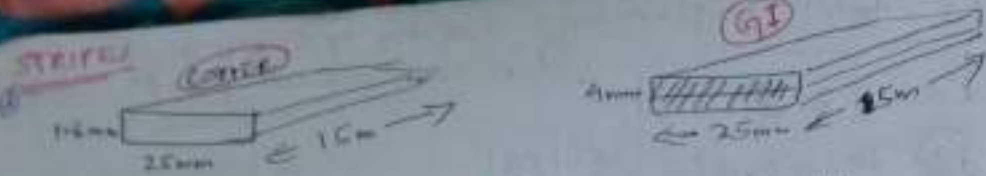
(#) Methods of Earthing

(1) Strip/Wire Earthing —

GI - Galvanized Iron
→ coating of "Zn" over iron/steel wire to prevent against "corrosion."

STRIPS

(i)

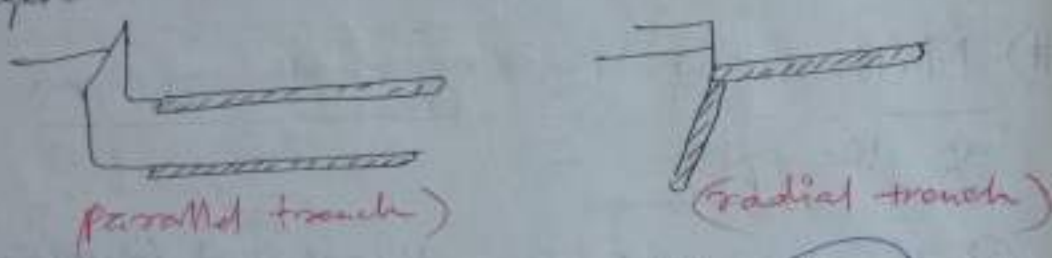


(a) Buried horizontally @ "0.5 m" depth.

Wire/Round Conductor

(ii)

(b) The length should be sufficient to give the required earth resistance.



(c) Such type of earthing used in (ROCKY) soil as excavation is not possible.

(2) Rod Earthing

→ Buried vertically atleast to 2.5 meters

→ More than one rod can be used to reduce earth resistance

→ Suitable for (SANDY) soil.

→ Cheap & no excavation is required.

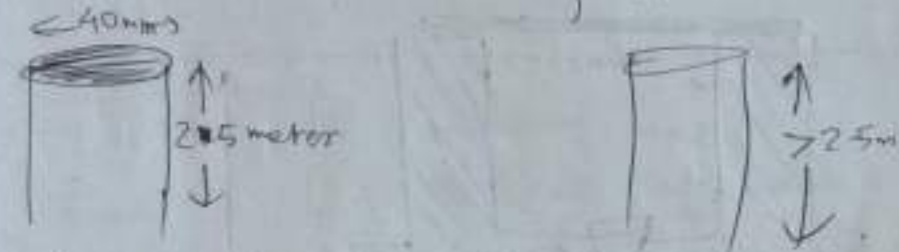
→ Hammered down by pneumatic ha...

(3) Pipe Earthing

→ For earth with moisture condition.

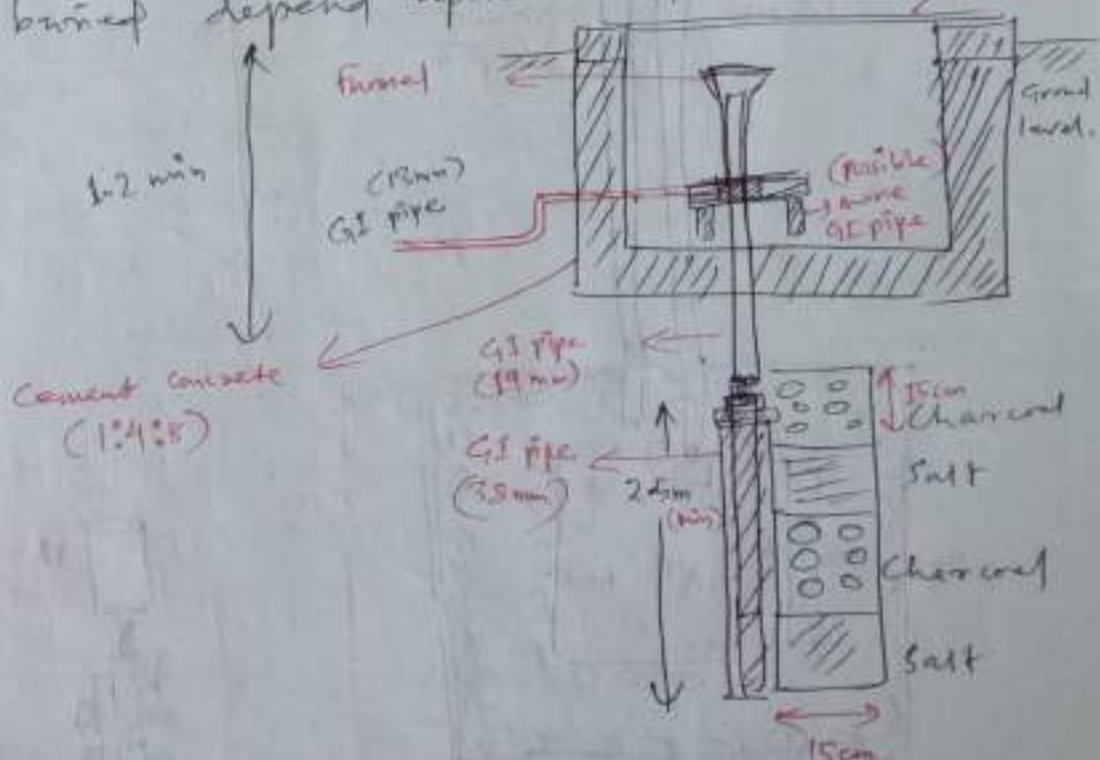
→ GI steel pipe or perforated pipe ~~is~~ placed upright permanently.

→ The size of pipe ∝ { Current rating, Type of ~~s~~ soil }



ordinary soil (Dry soil & rocky soil)

→ The depth at which pipe must be buried depend upon moisture level.

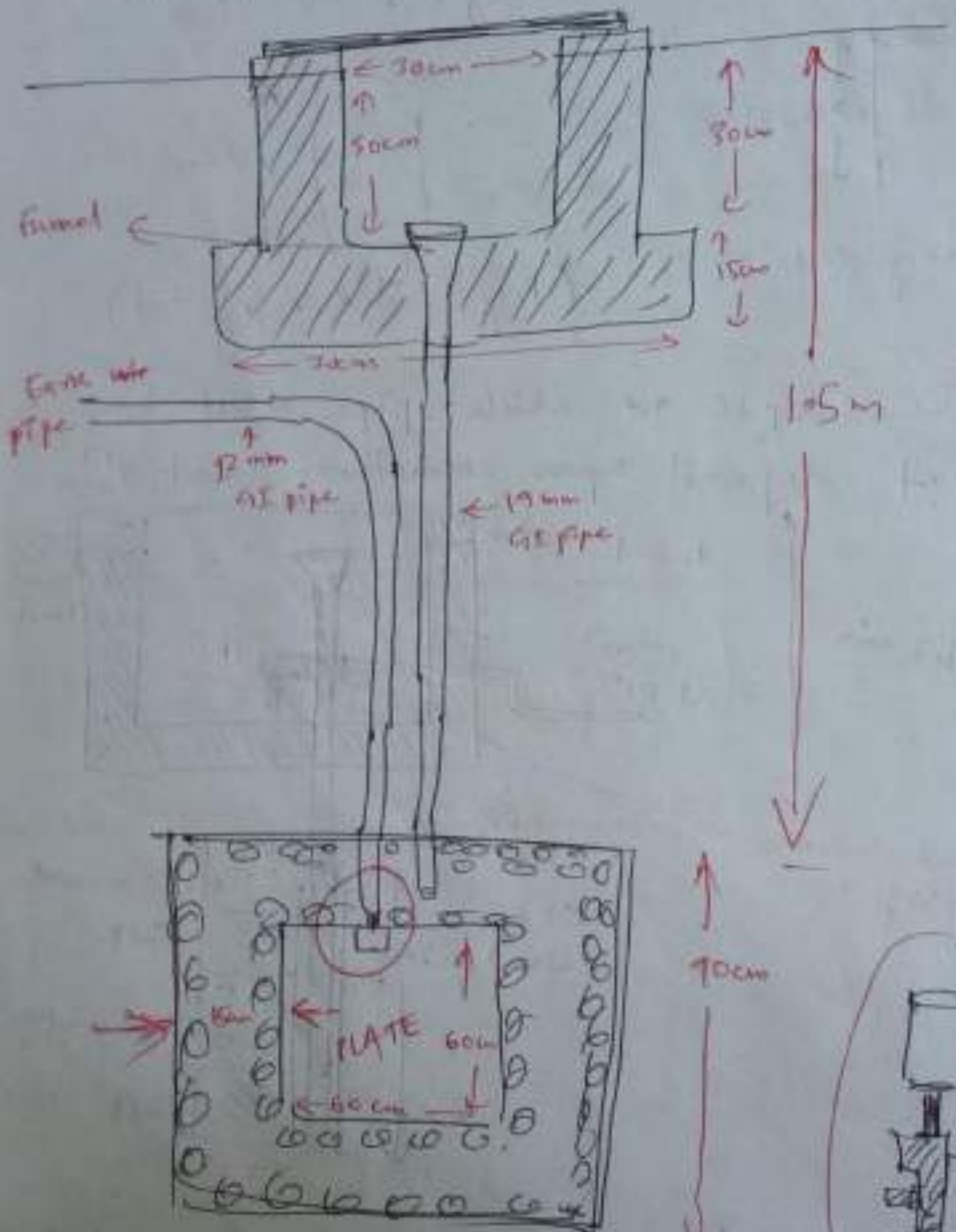


→ 3/4 bucket of water should be poured to keep the ~~+~~ soil moistured.

(42)

(a) Plate Earthing

→ Placed atleast 3m below the ground Vertically



* Aim

(1) Promote work & activities carried on within the buildings.

(2) Promote safety of ppl in using the buildg

(3) Decoration, a pleasing environment conducive to interest & sense of wellbeing.

* How to achieve

(1) Plan brightness pattern

(2) Form & texture in the task area.

(3) Controlling glare, stroboscopic effect & glim

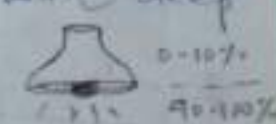
(4) Color rendering (Original color of object)

(5) Lighting for movement.

* Type of lighting scheme - (Image back side)

(I) Direct lighting -

-> More than 90% of light made to fall directly on working space with deep reflector.



-> More efficient but
- Hard shadow
- Glare

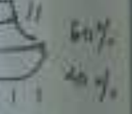
-> Industrial & outdoor activities.

(II) Semi-direct lighting -

-> 60-90% of light made to fall on the working area & remaining illuminate the wall & ceilings.

(III) Semi-Indirect lighting

→ 60-90% of total light flux thrown upward to the ceiling.



→ For soft shadow & glare free

→ Indoor light decoratⁿ.

(IV) Indirect lighting

→ More than 90% of total light is thrown upward, by inverted bowl reflector.

→ Ceiling act as light source, glare is reduced to minimum.

→ Softer illumination & more diffused.

→ Shadow is less prominent

→ Cinema hall, Hotel.

(V) General lighting

→ Equal illuminatiⁿ in all directⁿ.

→ Made up of diffusing glass.

Design of lighting scheme

(1) Illumination level (Bright color of obj is essential)

→ Necessary brightness is required by object.

→ (a) Size of object to be seen & its distance from observer.

(b) Contrast betⁿ object & background

Entrance / Hall → 100 (4)
(1) Living room → 300
Dining room → 150 (3)
(1) Bedroom → 300
Kitchen → 200 (2)
Bathroom → 150 (4)
(1) Bathroom - mirror → 300
Stairs → 100 (4)
Garage → 70 (5)
(1) Study → 300

Traffic

Group A1 → 30 (Imp route of Heavy traffic)
A2 → 15 (main road & mixed traffic)
B1 → 8 (2ndry road with considerable traffic)
B2 → 4 (Light traffic, 2ndry road).

(II) Uniformity of illumination

→ lack of uniformity → pupil / iris of the eye has to adjust more frequently → fatigue → productivity reduced.

→ loneliness, gloom & unfriendliness of wrong lighting (brightness).

(III) Color of light

→ Body color appearance is depends upon the incident light.

→ The composition of light should be such that the color appears natural.

(IV) Shadow

→ Formation of large & hard shadow cause fatigue to eyes.

→ ~~At~~ No shadow is also not desirable

→ Some shadow is required as it give shape to objects.

Hard & long shadow avoided

(i) → large nos of luminaries mounted at height of 2.5 meter

(ii) → Indirect lighting
→ Wide surface source light using globe over filaments.

(V) Glare

→ May be direct / indirect (reflected)

→ ~~Direct light~~ looking sun make eye discomfort but to moon (reflected glare).

→ Placing light at a height can be tolerated upto a limit.

→ Metal reflector for industrial lighting.

(VI) Mounting Height

→ Based on type of building & type of lighting.

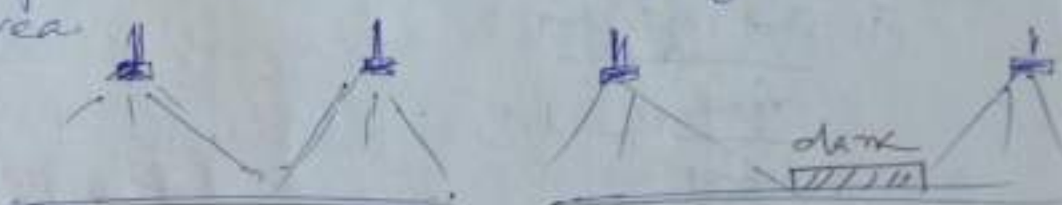
→ Bringing it down cause
(i) Non uniform lighting
(ii) Glare
(iii) less coefficient of utilization

→ Small room & high ceiling.
- bulb with reflector is best.

→ For indirect & semidirect lighting
- Bulb placed far below the ceiling to give uniform light on ceiling.
- 2.5 mtr clearance betn luminary & the floor

(VII) Spacing of luminaries –

→ Correct spacing is imp bcz to provide uniform illuminatn to do away with dark area.



$\frac{\text{Spacing}}{\text{Height}}$ = 1 → fluorescent light
0.6 → Tungsten lamp

$1\frac{1}{2}$ > → Indirect lighting

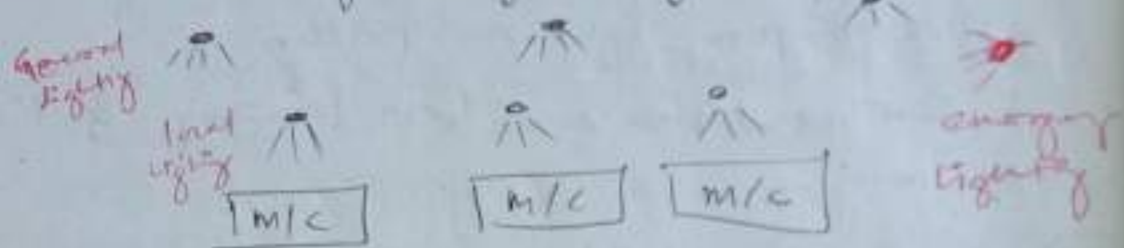
(VIII) Colour of wall –

→ Illuminatn of any room depends upon the colour of the wall & ceiling.

Factory lighting

→ Increase profit
→ Good visual environment for employee.
→ reduce accident

→ Proper distribution of light
→ ~~tob~~ glare avoided.
→ Avoid ~~g~~ single ct from any polish surface



→ Separate supply for emergency lighting.

(a) Industrial lighting fitting.

(i) Std reflector

$$\frac{\text{Space}}{\text{height}} = 1.5$$

(ii) Diffusing fittings – (glare free) As light diffuse through ~~coated~~ plastic / glass-coated.

Where highly polished articles is present

(iii) Concentrating reflector

For high ceiling; wide angle reflector may ~~do~~ waste light.

(iv) Angle reflector

~~Placed~~ provide illumination in vertical plane.

(b) Maintenance

→ Clean light fitting regularly.

→ 2 a week or more for dirty environment

(c) Types of lamp

→ Fluorescent ~~light~~ lamps for natural light colour, absence of glare, less heat than filament.

→ discharge lamp where "color rendering" is not important

electric discharge

Ability show natural colour of object

Street lighting

Objective

→ Na-vapour lamp

→ Mercury —do—

(1) To make traffic & obstruction clearly visible to promote safety

(2) To make street look attractive

Principle

(1) Diffusion Principle { road diffuse portion of light & appear bright.

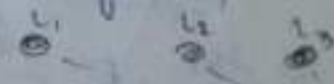
→ Direct light with uniform distribution

→ 30° to 45° cut-off reflector are made to such that filament is not visible except from underneath.

(2) Specular reflection principle

→ reflector → wide angle of incidence

→ L_1, L_2 will make the object look darker/shadow & more



Method of producing light (2)

(1) Arc betn two electrode

Arc lamp (Carbon Al), Neon lamp.

(2) Passing current through filament

Incandescent lamp (temperature) (Tungsten), Halogen

(3) Discharge thgh vapour/gas

- Sodium-vapour lamp (High voltage @ start to establish discharge)
- Mercury Vapour lamp
- Fluorescent lamp
- CFL

Reflection factor

$$\frac{\text{Reflected light}}{\text{Incident light}}$$

Law of Illumination (1)

→ luminous intensity

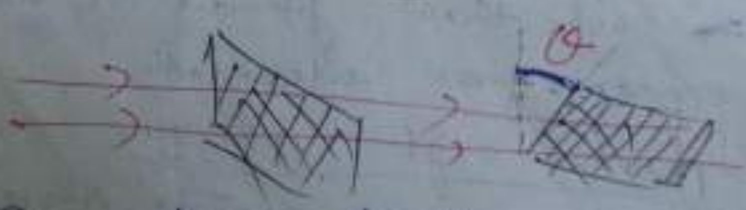
→ Dist. betn source & surface

→ Direction of ray of light

(1) Inverse square law

Illumination $\alpha \frac{1}{d^2}$ → dist betn source & surface

(2) Lambert's cosine law



Cosine angle of direction of ray of light & the ⊥r ~~area~~ to the

(Direct) (Indirect) (Semi-direct) (Semi-indirect)

Utilization factor

$$UF = \frac{\text{lumen reached surface}}{\text{lumen emitted by source}}$$

0.5 to 0.8

Absorption by wall, ceiling, diffuser.

Depreciation factor

Due to the passage of time, dust deposition on wall & surface reduces the lumen.

1.3 to 1.6

Space-height ratio

$$S\text{-}H = \frac{\text{Space betn lamps}}{\text{height from the surface}} \quad (1 \text{ to } 1.5)$$

— Public lighting installatn (18-136)

INTERNAL WIRING ESTIMATION

General rules for wiring

(1) Protectn @ entry of cable by "two pole linked main switch" & "fuse".
"3 pole switch" for 3ϕ supply.
No CB or fuse in neutral/earthed wire.

(2) Conductor size depends upon the load current

(3) Sub-ckts are connected to DB (dist board).

(4) Every line is protected by suitable rated fuse

(5) Switch board - 1.5m above the floor.

(6) 3-pin socket outlet

Light & fan ckt ⇒ 5A
Power sub-ckt → 15 A

- Controlled by individual switch, immediately adjacent
- Shuttered/interlock sockets are used ~~use~~ where it is ~~also~~ accessible to children.
- For higher rating (>15A) socket; a double pole switch is connected. (Table 8.2)
- Socket outlet are placed 25 cm or 1.3 mtr above the floor level.
- In bathroom No SO is provided below 1.3 mtr

(x) 3-pin 15A SO provided in kitchen

(7) Incandescent ~~light~~ lamps, ~~hung~~ hung at height 2.5 mtr from floor level.

(8) Ceiling fan at 2.75 mtr height.

(9) Each subckt has less than 10 point or

(11) Every apparatus is provided with switch for isolation.

(12) Light & fan wiring and power wiring are kept separated (bcz distinct wire gauge is used)

(13) In 3ϕ 4W installation; load is distributed equally on all the phases.

(14) Metal sheath & conduit for all wiring & metal covering are to be properly earthed.

(15) Each sub ckt is protected by separate fuse/CB.

(16) After completion of installation are to be tested before energization.

* Determinati of Number of point

(1) Light
→ size of room, illumination level.
→ luminous efficiency of the lamp to be used

(2) Fan
→ Size of room (Table 8.1)
→ Size of fan
(3 Air-exchange per hour)

* Determinati of total load

(1) CFL - 50W

(2) Incandescent, fan, socket outlet - 60 W

* Determination of Sub-ckt

① Number of point (if exceed 10 point then New SC)

② Load (if exceed 800W ; New SC)

* Determination of size of conductor

① Minimum size for Mechanical reason

Copper wire $\geq 1/1.22$ mm (Number of strand / dia of each strand.)

Al wire $\geq 1/1.4$ mm

Flexible cord $\geq 14/0.193$ mm

② Current carrying capacity :

It should carry max current continuously without overheating.

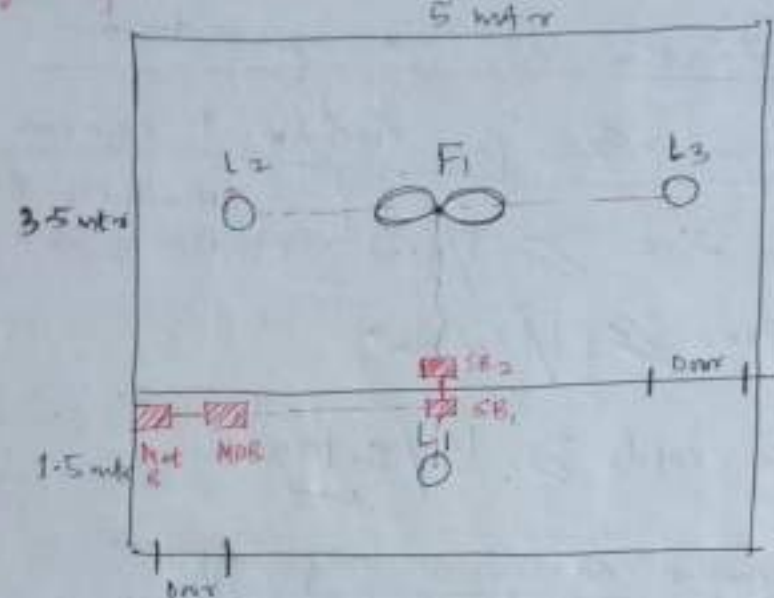
③ Voltage drop

Max allowed $V_{drop} = 2\%$ of V_{supply}

$V_{drop} = 5\%$ ~~Vdrop~~ V_{supply} (Power Wiring)

[V_{drop} (AC) > V_{drop} (DC) ∵ L, C]

* Prepare one estimate for CTS wiring for small domestic installation of one room & one Verandah within $25m^2$ with given light, fan, socket.



Assumption ;

Taking 10 watts/m^2 of surface area as illumination :

So; Total area = $5 \times 5 = 25 m^2$

Total Wattage = $25 \times 10 = 250$ watts

3×100 watt bulb will be sufficient

One ceiling fan = 1×60 watts.

One socket in Verandah = 100W

Two ~~Two~~ sockets (~~One power +~~ One power One light) in room.

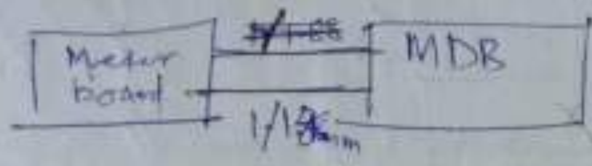
→ $100 + 1000$ ~~110 + 1000~~ = ~~1100 watts~~ 1100W

Total power consumption = $250 + 60 + 100 + 1100$

⇒ P = ~~1510 watts~~ ~~510W~~ 1510

Supply voltage = 240V

So; 1/1.8 mm, 1-core, 650V grade
↳ Aluminium conductor PVC cable
18 Amp current capacity is chosen to ~~for~~ used in between



~~One~~ ~~Two~~ switch board are used
Two ~~One~~ ~~$SB_1 \rightarrow$ verandah~~
~~$SB_2 \rightarrow$~~

as there are $3+1+2 = 6$ points
& power = 510 watts

LIGHTING

Lumen = Lux * Area
(Illuminous flux) (Illuminance)

Illuminance = Luminous flux / Area

Location	Lux
Entrance/Hall	100
Living room	300
Kitchen	200
Bathroom	100
Study	300

Lumen	Incandent	CFL	LED
450	40W	10W	5W
800	60W	15W	7W
1100	75W	20W	10W
1600	100W	25W	18W
2600	150W	~~30-55~~ 40W	26W

Ex 15m X 6m Hall

Area = 15X6 = 90m²

for hall (Lux) = 100

Lumen = 90 X 100 = 9000

Choosing (100W - Incadent bulb)

~~for~~ Nos of bulb = 9000

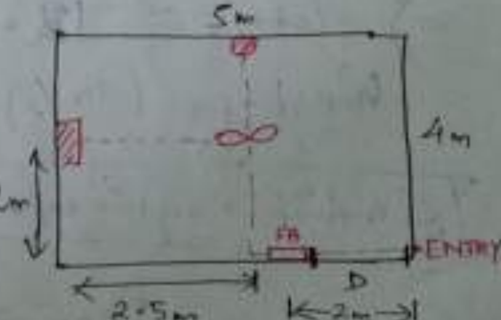
* WIRING

Few Standards

1. Switch board – 1.5 mtr above floor.
2. Tube / bulb – 0.5 mtr below the ceiling.
3. Fan – On the ceiling.
4. Switchboard – (near door).
5. bulb = fan = socket (5A) ≃ 60 W
6. Meter board to MDB = 0.2 mtr.
7. Door = 1 mtr

Q. 5m X 4m X 3.5m room.
1 Lamp, 1 fan, 1 CFL tube, 5A socket = 1
Draw wiring.
Calculate total wire & conduit.
Prepare a list of material & their cost.

Ans



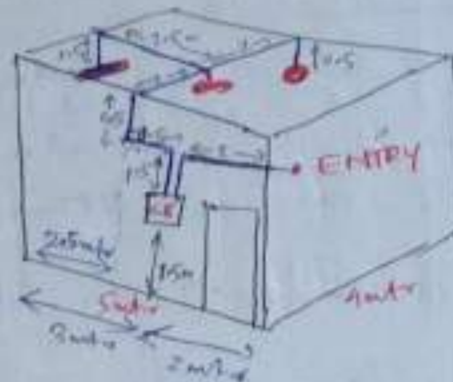
Few assumption

(i) SB is placed 1.5 mtr above floor

(ii) Tube/bulb are located 0.5 mtr below ceiling

(iii) Horizontal Run (HR) from floor = 3 mtr
(from ceiling = 0.5 mtr)

(iv) Vertical Run (VR) = 3 − 1.5 = 1.5 mtr.
(SB to HR height)



length of conduit

From entry point to HR = 2 mtr

SB to HR = 1.5 mtr

HR to take off point = 0.5 mtr

take off to Fan = 0.5 + 2 = 2.5 mtr

Fan to bulb = 2 + 0.5 = 2.5 mtr

Fan to Tube = 2.5 + 0.5 = 3 mtr

Total = 2 + 1.5 + 0.5 + 2.5 + 2.5 + 3

=> Total = 12 mtr

Wastage (10%) = 1.2 mtr

$\boxed{\text{Conduit required} = 12 + 1.2 = 13.2 \text{ mtr}}$

length of phase wire

Entry to SB = 2 + 1.5 mtr = 3.5 mtr

SB to fan = 1.5 + 0.5 + 0.5 + 2
= 4.5 mtr

SB to bulb = 1.5 + 0.5 + 0.5 + 4 + 0.5
= 7 mtr

Total wire = 3.5 + 4.5 + 7 + 7.5
= 8 + 14.5

$\boxed{\text{Phase} = 22.5 \text{ mtr}}$

Length of neutral wire

Entry to SB = 2 + 1.5 = 3.5 mtr
SB to fan = 1.5 + 0.5 + 0.5 + 2
= 4.5 mtr
Fan to tube = 2.5 + 0.5 = 3 mtr
Fan to bulb = 2 + 0.5 = 2.5 mtr

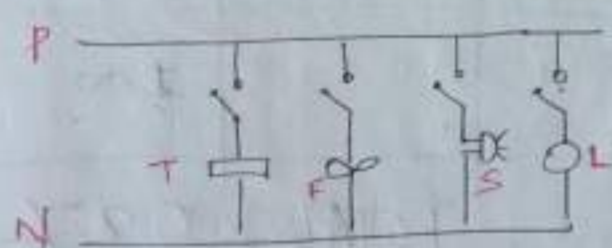
Total neutral = 3.5 + 4.5 + 3 + 2.5
= 8 + 5.5

$\boxed{\text{Neutral} = 13.5 \text{ mtr}}$

Total wire = P+N = 22.5 + 13.5
= 36.0 mtr

15% wastage = $36 \times \frac{15}{100}$ = 5.4 mtr.

$\boxed{\text{Grand total wire} = 41.4 \text{ mtr}}$



Diameter of wire

Total load = $\overset{L}{60} + \overset{F}{60} + \overset{\text{cooler}}{100} + \overset{\text{CFL}}{40}$ = 260 W
Vsupply = 240V
~~Iphase~~ I line = $\frac{240}{240}$ = 1.2 Amp
[1/1.4mm Al = 10 Amp (Cheap)]

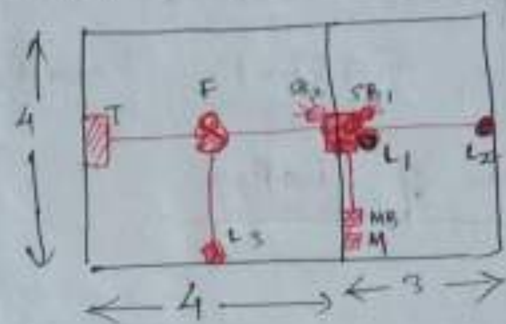
Materials Required	Quantity	Cost
① Conduit pipe 20mm	14 mtr	12 /mtr = 168
② PVC insulated 1/1.4 mm Aluminium Conductor, 1 core	42 mtr	2 /mtr = 84
③ Switch board (Iron clad) (20 X 25 cm²)	1 No.	50
④ Conduit pipe (20mm) Accessories		100
⑤ Ceiling rose (Tube - fan)	2 No.	5
⑥ Lamp holder	1 No	15
⑦ Screw		5
⑧ Bolt & Nuts		10
⑨ Labour charge		100

TOTAL = 537

10% Extra = 55

Grand total = 592

Q/ A room, Verandah
(4X4) (4X3)
Design a suitable electrical w/w.
Prepare a list of materials required
Meter & main switch are to be available.
(Batten wiring)



Load

Room : T, F, L_3, S(5A)
Verandah : L_1, L_2, S(5A)

7 points

Assume :

Height of ceiling = 3.5 m
— do — HR from floor = 3 m
— do — SB — do — = 1.5 m
Meter & Main switch board — 0.5 mtr inside the wall

Load Calculation

$$\text{Lamp} = 3 \times 60 = 180$$
$$\text{Tube} = 1 \times 40 = 40$$
$$\text{Fan} = 1 \times 60 = 60$$
$$\text{Socket (5A)} = 2 \times 100 = 200$$
$$\text{Power} = 480 \text{ Watts}$$

$$I_{phase} = \frac{P}{V} = \frac{480}{240} = 2A$$

Selection of main switch

DPIC of 5Amp, 240V grade

Selection ~~*~~ and rating of distribution board

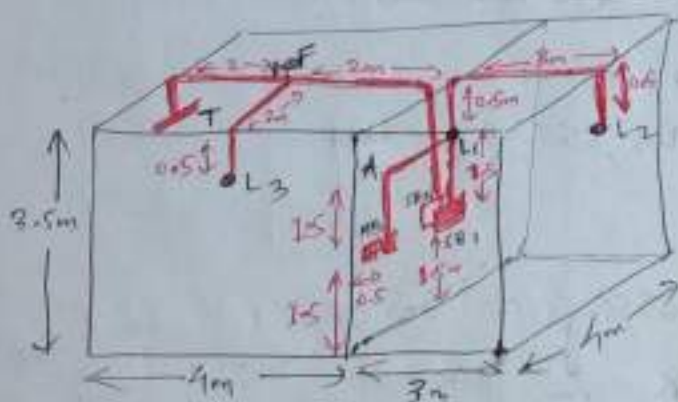
Total point = 7

Total load = 480 W

No separate sub, ckt is required

So, No distribution board.

* Length of Batten



2W → 13 X 13 mm²
4W → 25 X 13 mm²
5W → 31 X 13 mm²
3W → 20 X 13 mm²

(i) Main switch board to ~~MSB~~ L_1 (Via A) $\boxed{= 2 \text{ Wire}}$ (1L+1N)

$= [1.5 + (2 - 0.5)] m * 13 mm * 13 mm$

$= 3 m \times 13 mm \times 13 mm$

(ii) L_1 to SB_1 (2W + 2L + 1N = 5 Wire)

$= 1.5 m \times 31 mm \times 13 mm$

(iii) L_1 to L_2 (1L + 1N = 2 Wire)

$= 4 m \times 13 mm \times 13 mm$

(iv) SB_2 to Fan (3L + 1N = 4 wire)

$= (2 + 2) m \times 25 mm \times 13 mm$

$= 4 m \times 25 mm \times 13 mm$

Total length of batten size

$13mm \times 13mm = 3 + 4 + 2.5 + 2.5 = 12$ mt.

$25mm \times 13mm = 4$ mtr

$31mm \times 13mm = 1.5$ mtr

Wastage 10%

$13 \times 13 \, mm^2 = 12 + 1.2 = 13.2 \, m \simeq 13 \, m$

$25 \times 13 \, mm^2 = 4 + 0.4 = 4.4 \, m \simeq 5 \, m$

$31 \times 13 \, mm^2 = 1.5 + 0.15 = 1.65 \, m \simeq 2 \, m$

* Length of wire

$13 \times 13 \, mm^2 \to 12m \times 2W = 24 \, m$

$25 \times 13 \, mm^2 \to 4m \times 4W = 16 \, m$

$31 \times 13 \, mm^2 \to 1.5 \times 5W = 7.5 \, m$

$47.5 \, m$

crossing wall SB_1 to SB_2 $= 2W \times (0.25m) = 0.5m$

$48 \, m$

15% wastage $= \frac{48 \times 15}{100} = 7.2 \, m$

$\boxed{\text{Grand total} = 55.2 \text{ mts}}$

* Earth wire

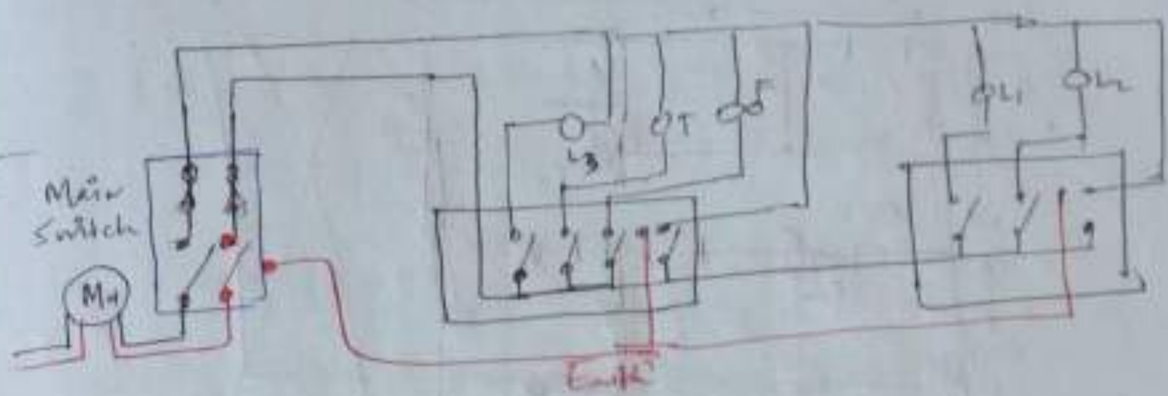
14 SWG of galvanized iron.

Installed on same batten.

MS to SB_2 via SB_1

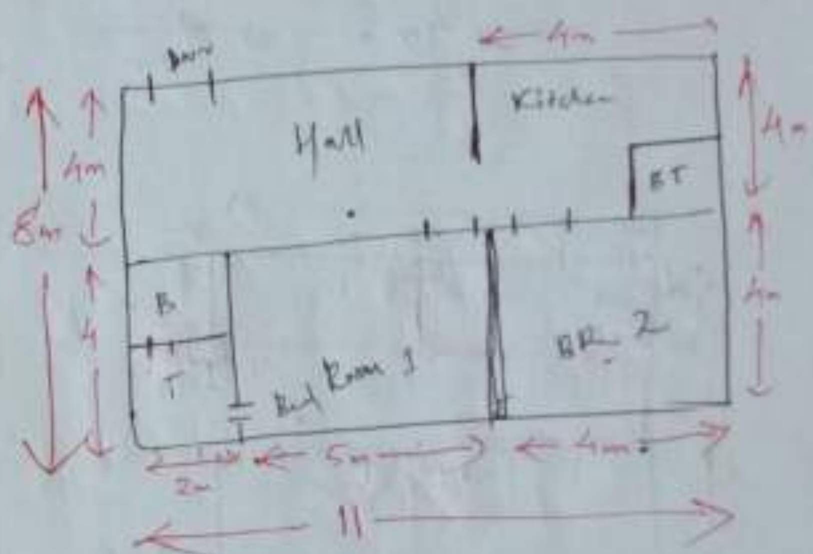
* Material Table

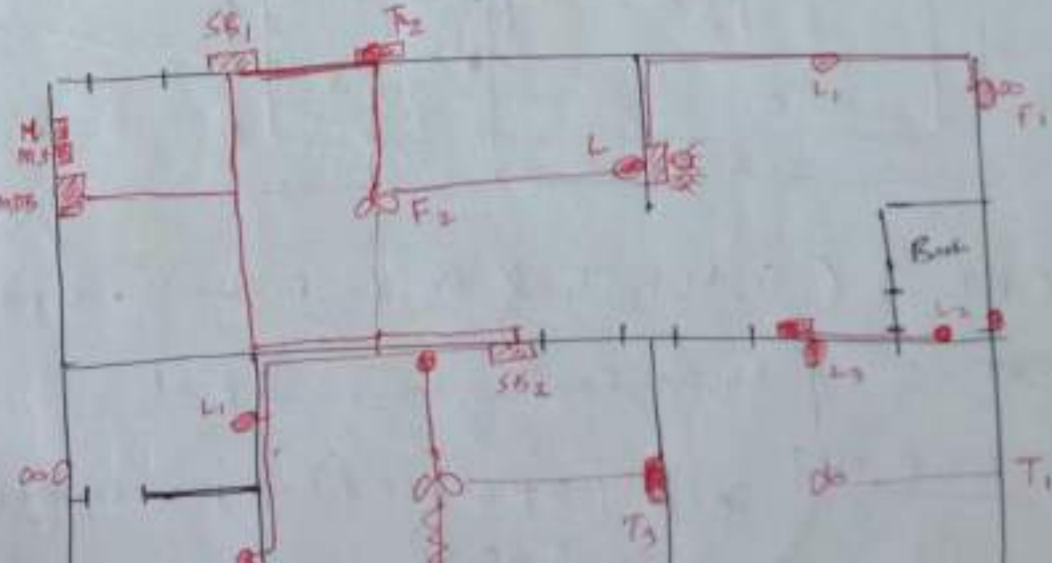
S No.	Specification		Qty
1.	DPIC (5A, 240V)		1
2.	meter board (30cm X 30cm)		1
3.	Batten	$13 \times 13\ mm^2$	13m
		$25 \times 13\ mm^2$	5m
		$31 \times 13\ mm^2$	2 mtr
4.	C.T.S wire $1.5\ mm^2$ (1/1.4mm Al)		56 mtr
5.	Earth wire (14 SWG GI)		5 mtr
6.	Conduit pipe (20mm) wall crossing		0.25 mtr
7.	Switch board cover (20cm X 20cm)		2
8.	Socket (5A, 3pin)		2
9.	Switch (5A)		~~6~~ 7
10.	Ceiling Rose (T of F)		2
11.	Lamp bracket of holder		2
12.	~~cl~~ link clips (Al - 40mm long) 10 cm apart		300
13.	Nail to fix clips		50 gm ~~[illegible]~~

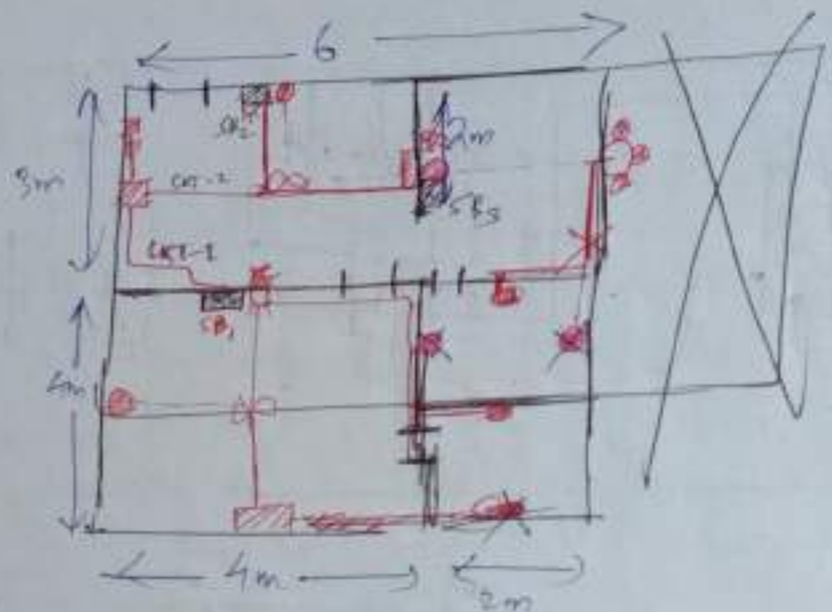


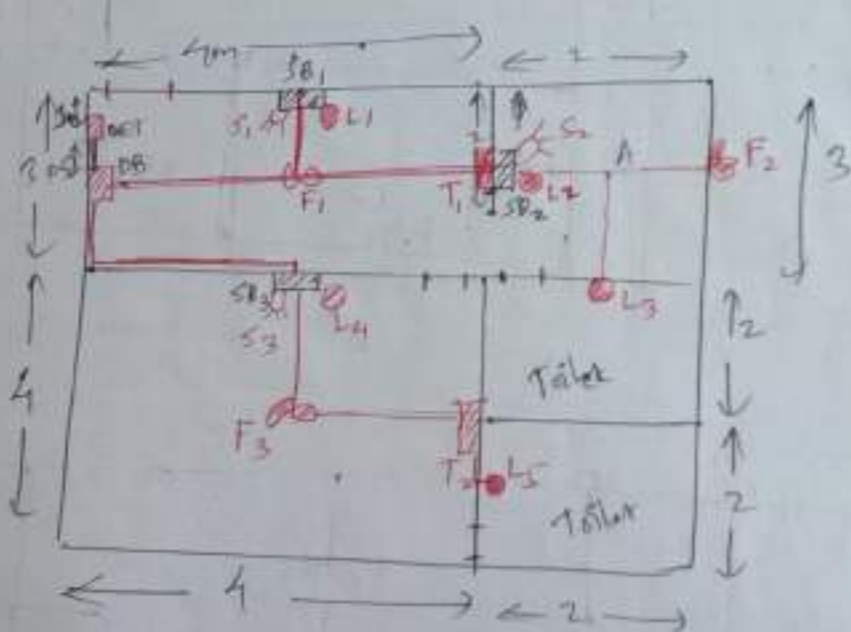
*Height = 3.5 meter

Plan Lighting









CKT - 1 (S_1, L_1, F_1, T_1 & S_2, L_2, F_2, L_3) - 8 point

CKT - 2 (L_4, S_3, F_3, T_2, L_5) - 5 point

(15). Total load CKT 1 = 100 + 60 + 60 + 40 + 100 + 60 + 60 + 60

= 540 W

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$I_{phase} = 3.6$ Amp

2 way, 240 Volt, 16A IC distribution board is used.

1/1.8 mm Al conductor, single core is used (15 Amp) from meter to DB.

Few assumpt

Height of ceiling = 3.5 mtr

HR is below ceiling = 0.5 mtr

SB at height = 1.5 mtr

DB & meter at height = 1.5 mtr

Bulb, Tube at height = 0.5 mtr

Add everywhere

$VR = \underline{\underline{1.5}}$

(IMP)

Length of conduit

Meter to DB = 0.5 m

$$\left.\begin{array}{l} DB \text{ to } F_1 = 2\,m \\ F_1 \text{ to } SB_1 = 1.5\,m \\ F_1 \text{ to } T_1 = 2\,m \\ SB_2 \text{ to } F_2 = 2\,m \\ A \text{ to } L_3 = 1.5 \end{array}\right] \text{CKT-1}$$

$$\left.\begin{array}{l} DB \text{ to } SB_3 = 1.5 + 2 = 3.5\,m \\ SB_3 \text{ to } F_3 = 2 \\ F_3 \text{ to } T_2 = 2 \\ T_2 \text{ to } L_5 = 1\,m \end{array}\right] \text{CKT-2}$$

1h of ...

69

Length of phase wire

meter to DB
~~Meter~~ = $0.5 \times 2 = 1m.$

i) For CKT 1

DB to $SB_1 = 3.5$ m
SB_1 to $F_1 = 1.5$ m
SB_1 to $T_1 = 3.5$ m

~~DB to~~
F_1 to $SB_2 = 2$ m
SB_2 to $F_2 = 2$ m
SB_2 to $L_3 = 1.5$ m

(ii) For ckt-2

DB to $SB_3 = 3.5$.

Overhead Installation

Q/. Estimate the materials required for $3\phi, 4W$ overhead distribution line of 1.25 km length. Connect 110 kW load at 400V distributed along the route.

Draw neat sketch diagram & list the materials required.

Ans

Total load = 110 kW

Supply Voltage = 400V

Length of line = 1.25 km = 1250 m

Assuming 50 m span

$$\text{Nos of pole} = \frac{1250}{50} + 1 = 25 + 1$$

$$= 26$$

Nos of RCC pole required @ 50 m span are 26.

* ~~Ch~~ CS of conductor

$$I_L = \frac{P}{\sqrt{3}\, V_L} = \frac{110 \times 1000}{\sqrt{3} \times 400 \times \eta \times PF}$$

(Let PF = 0.8 & η = 0.85)

$\Rightarrow I_L = 233.5$ Amp.

$I_{st} = 2 I_L = 467$ A

∴ The choice of conductor is AAC Table 10.3

19/1×3.78 mm → 468 A range Page - 250

- Length of conductor (4w)

$= 4 \times 1250 + 2\%$ sag

$= 5000 + \frac{2}{100} \times 5000$

$= 5100$ m

- Length of Earth wire

$= 1250 + 2\%$ Sag

$= 1275$ m

PCC – Plain cement concrete

Material required

	Items	Qty	Unit
1.	RCC Pole (9m)	26	Nos
2.	ACC conductor (19/2.78mm)	5100	m
3.	Earth wire (8 SWG)	1275	m
4.	LT cable (4 core, 185 mm²) (Tf to Pole (nearest))	15	m
5.	Earthing Set	2 Nos (Start of & End).	
6.	LT cable box for 4 core - 185mm²	1 Nos	
7.	Stay set	2×2=4 (2 on each pole)	
8.	Pole concrete	26	Nos

Q/. Prepare an estimate of a distribution line with street lighting is to be distributed by 3ϕ, 5W, 200 KVA, 0.8 PF over a distance of 2 km.
Calculate size of ACSR conductor & prepare a list of material used.

Ans. 6W = 3ϕ + 1 N + 1 for lighting + 1 Earth wire

Length = 2 km = 2000 m

$$\text{Pole} = \frac{2000}{50\ (\text{Span})} + 1 = 40 + 1 = 41$$

height of PCC pole = 9 m

Total load = 200 KVA * 0.8
= 160 KW

$$I_L = \frac{160 \times 10^3}{\sqrt{3}\,(400)\,(0.8)} = 288.67\,A$$

$$I_{st} = 1.5 \times I_L = 433\,A$$

Conductor choosen from "Table 10.4" (Pg-251)
Panther (30/7 × 3.00) = 21 mm diameter

The length of 3ϕ 4W = 4×2000 + 2% sag
= 8000 + 160 = 8160 m

Q/. A 1km long overhead line
"Est. 10.9" Page - 297

Data given :-

Length of line = 1km = 1000 mtr
Average span = 50 mtr
Nos of towers = $\frac{1000}{50} + 1 = 21$
(RCC)
→ 9 mtr height

length of ACSR (6/1 × 3mm)
required = 3 × 1000 + 2% sag
= 3000 + $\frac{3000 \times 2}{100}$
= 3060 mtr

Neutral wire length = 1000 + 2% sag
(6/1 × 2.11mm)
= 1020 mtr

Length of Earth wire = 1000 + 2% sag
(8 SWG) (GI)
= 1020 mtr.

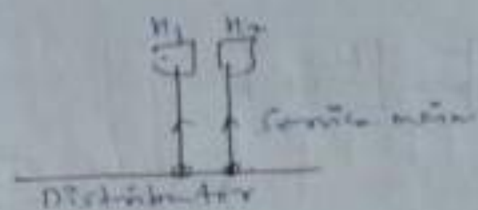
Materials

1. RCC pole
2. 7/3.mm ACSR
3. 7/2.11mm ACSR
4. 8SWG GI
5. LI shackle insulator = 21 × 4 = 84.
6. Earthing set = 4

* Tee-off

tee off is the ~~point~~ junction ~~from which between~~ distribution line & service main.

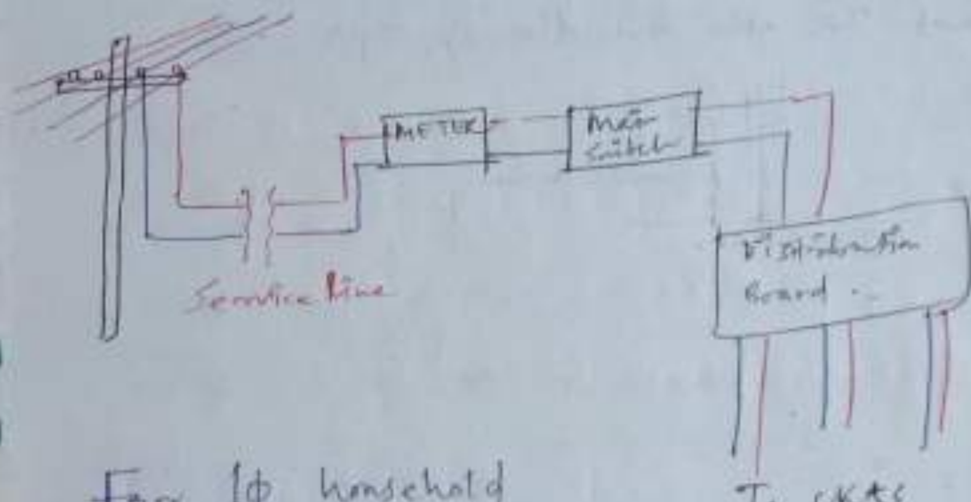
It should be ~~taken~~ near the pole & not in the middle of span.



Overhead Service Line

→ Service line is the intermediate between distributor & consumer end.

→ Weatherproof cables are used



EIE

For 1ϕ household

3 wire Line, neutral, Earth

For Workshop, factory

5 wire = 3ϕ, N, E

(I) **Overhead SL**

Copper - 10 SWG - 1 KW

AAC/ACSR - 8 SWG - 2.5KW
(14 mm²) (Copper)

AAC/ACSR - Copper - 12 KW
(19.4 mm²) (6 SWG)

Weather proof / PVC cable are used.

(II) LT $3\frac{1}{2}$ core cable for underground SL.

* Method of Installation

(1) (i) High roof buildings

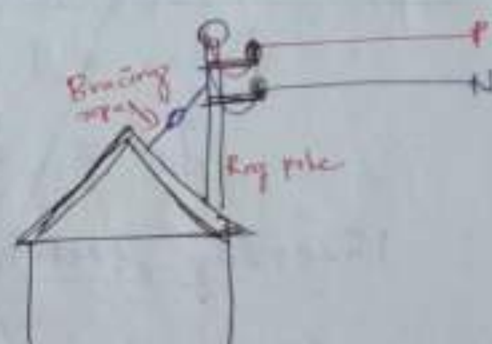
Service bracket is embedded on the wall at suitable height. Shackel type insulator are fitted on the wall.

Distance betn insulator

: Vertical - 35 cm lateral - 30 cm ...

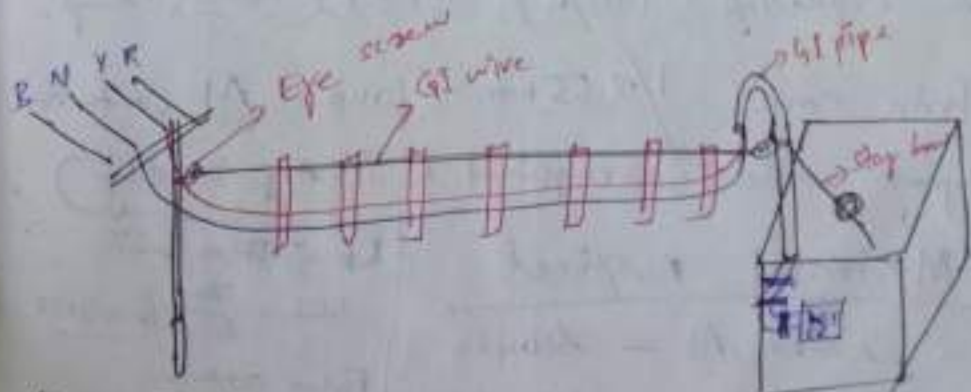
(ii) Low roof / 1 Stored building -

Service bracket can be fixed on the wall. Roof pole is fixed on the top (within 3m) braced by steel rope

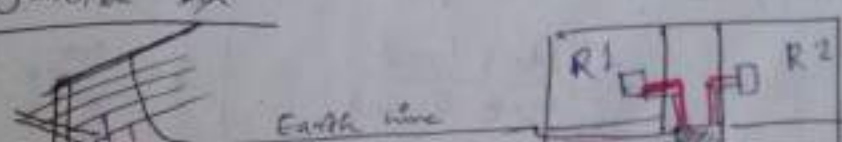


(iii) Weatherproof Cable

8 SWG GI wire Service pole to eye screw bolt



(iv) Junction box



Q. Ex 12.1 (Pg - 333)

1 Storied building

$V_s = 240$ Volt

load $= 5$ kW, 50 Hz

Pole to meter board $= 20$ meter

Assume -

Height of building $= 3.5$ mtr

SL received at height $= 6$ mt from floor.

Electrical load $= \frac{5000}{800} = 5$ Sub ckt $+ 1$ (15 Amp Socket)

(X) $= (4000 + 1000)$ Watts.

Selection of cable

Power of load $= 5$ kW.

$$I_L = \frac{5000}{240} = 21.7 \text{ Amp}$$

Diversity factor (60% used at a time) of installed capacity

So;

$I_d = 21.7 \times 0.6 = 13$ Amp.

future expansion $(100\%) = 13 \times 2 = 26$ Amp.

So; Twin core 1/3.55 mm ($10 mm^2$) Al conductor Weatherproof cable is required (34 Amp rating).

*** Materials required**

$10 mm^2$, 2 core, Al $= 40$ mtr

8 SWG, GI wire $= 40$ mtr

Diversity factor $= \frac{\text{Total load}}{\text{Max demand}}$

Let; DF $= 1.67$

$1.67 = \frac{5000}{P_m}$; $P_m = 3000$

Future expansion

$= 3000 \times 2 = 6000$ W.

$I_L = \frac{6000}{240} = 25$ A

Q/. Est 12.2 (Pg 334)

Double stored building

Load is 4KW, 240V, 50Hz

Separate meter for each floor.

Pole - building = 12 m

Service bracket - Service board = 10 m

Load = 4KW

1.6 diversity factor of 100% future growth

$$\text{Load} = \frac{4 \times 1000}{1.6} \times 2 = 5000\,W$$

$$I_L = \frac{5000}{240} = 20.833\ \text{Amp}$$

2-core 1/2.8 mm (6 mm²) Al cable (27 rating)

* Material required

- 6mm² - cable = 12+10+3 = 25 meter
- Aerial fuse (32A) = 1
- GI pipe 50 mm dia = 4 meter

Q/. Est 12.4 (Pg - 337)

3φ, 37 KW, 415 V, 50Hz

~~Stand~~ Structure - pole = 15 m

$\eta = 85\%$ PF = 0.8

$$I_{motor} = \frac{37 \times 1000}{\sqrt{3} \times 415 \times 0.85 \times 0.8} = 75.7\ \text{Amp}$$

$$I_{st} = 1.5 \times 75.7 = 113.6\ \text{Amp}$$

Conductor : $3\frac{1}{2}$ core, 35 mm², 1100 Volt Al

Length of cable required

= Pole – ground + length along trench

+ vertical run upto cable box + wastage

= 6 + 15 + 2 + 3

= 26 meter

SUBSTATION

Energy in HV → [SS] → LV distribution

Classification

(1) Nature of duties

(i) Step up (1°)

Generating station ($11/220$ kV)

(ii) 1° Grid SS

located @ suitable load centre along 1° transmission line.

It is connected to 2° tL / 1° distribution line.

(iii) Step down / distribution SS

11 kV/415 Volt.

Located @ load centre.

: 1° dist line [SS] 2° distribution line.

(2) Basis of Service

(i) T/F substation

t/f are installed on each SS to stepup or step down power.

(ii) Switching SS

→ For switching purpose.

→ Various tL are interconnected in SS.

(iii) Converting SS

AC to DC or DC to AC

③ Operating Voltage

(i) HV SS – 11 kV – 66 kV

(ii) EHV SS – 132 kV – 400 kV

(iii) Ultra High Voltage (UHV) -> 400 kV

④ Basis of Design

① Indoor type

Within a building

11 kV – 33 kV.

Surrounding with impurities (metal corroding gas dust)

② Outdoor type

(A) Pole mounted

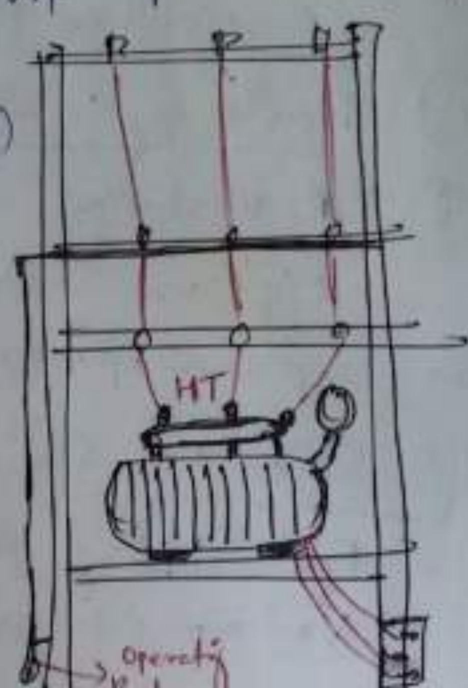
-> distribution of power in localities.

Rating 25 kVA – 125 kVA upto 250 kVA

-> TPMO switch fuse (Tripple pole mechanically operated) switching 'ON' & 'OFF' of HT line.

-> LA (Lighting Arrestor) are installed over HT line to protect.

-> 125 kVA – 2 pole
250 kVA – 4 pole



(B) Foundation mounted SS

- Above 250 KVA rating TF
- Structured on the ground.
- Covered by Fences.
- For 1° & 2° transmission (Bulk power).
- Very high voltage of operation
- CB & isolator are provided for maintenance.