UNIT–I

INTRODUCTION TO BUILDING SERVICES

Definitions, Objective and uses of services, Classification of building services, Types of services and selection of services, Natural and artificial lighting – principles and factors, Necessity of Ventilation (HVAC), Types of ventilation – Natural and Mechanical, Factors to be considered in the design of Ventilation.

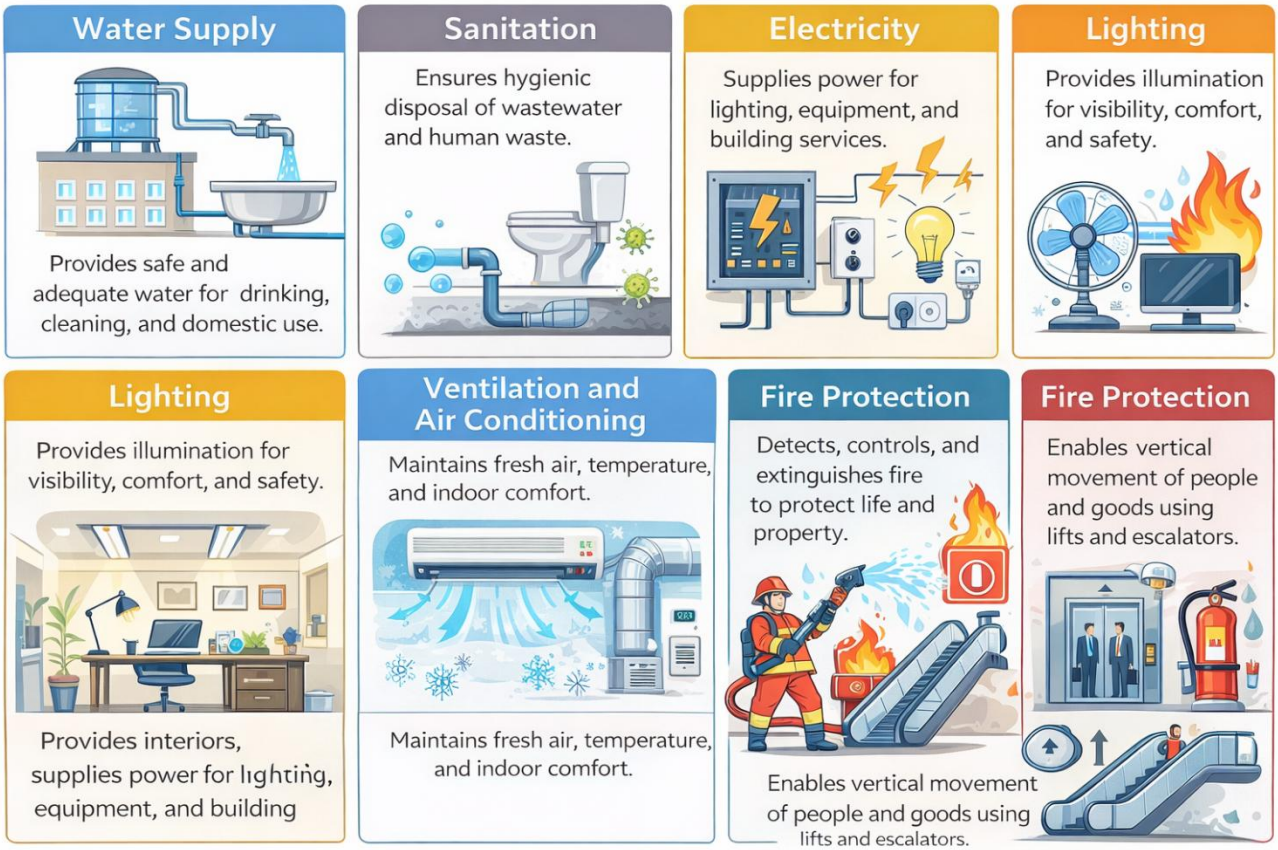
1. Introduction to Building Services

A building is not complete by structural components alone. **Building services** are essential systems provided in a building to make it **comfortable, safe, healthy, and functional** for occupants.

Building services integrate **engineering systems** with architectural and structural elements to support human activities inside buildings.

Examples:

- **Water supply:** Provides safe and adequate water for drinking, cleaning, and domestic use.
- **Sanitation:** Ensures hygienic disposal of wastewater and human waste.
- **Electricity:** Supplies power for lighting, equipment, and building services.
- **Lighting:** Provides illumination for visibility, comfort, and safety.
- **Ventilation and air conditioning:** Maintains fresh air, temperature, and indoor comfort.
- **Fire protection:** Detects, controls, and extinguishes fire to protect life and property.
- **Vertical transportation:** Enables vertical movement of people and goods using lifts and escalators.



2. Definition of Building Services

Building Services are defined as:

The systems and installations provided in a building to ensure comfort, safety, hygiene, efficient operation, and convenience of occupants.

In simple terms, building services are the **utility services** that allow a building to be **used effectively**.

3. Objectives of Building Services

The main objectives are:

3.1 Comfort:

Building services ensure occupant comfort by providing proper lighting, maintaining a comfortable indoor temperature, and supplying adequate ventilation.

3.2 Health and Hygiene:

Building services supply clean drinking water, remove wastewater and sewage, and maintain healthy indoor air quality.

3.3 Safety:

They ensure safety through fire detection and firefighting systems, electrical safety measures, and emergency facilities.

3.4 Functional Efficiency:

Building services support smooth functioning of residential, commercial, and industrial buildings with efficient movement of people and materials.

3.5 Energy Efficiency:

They help reduce power consumption and promote sustainable and energy-efficient building practices.

4. Uses of Building Services

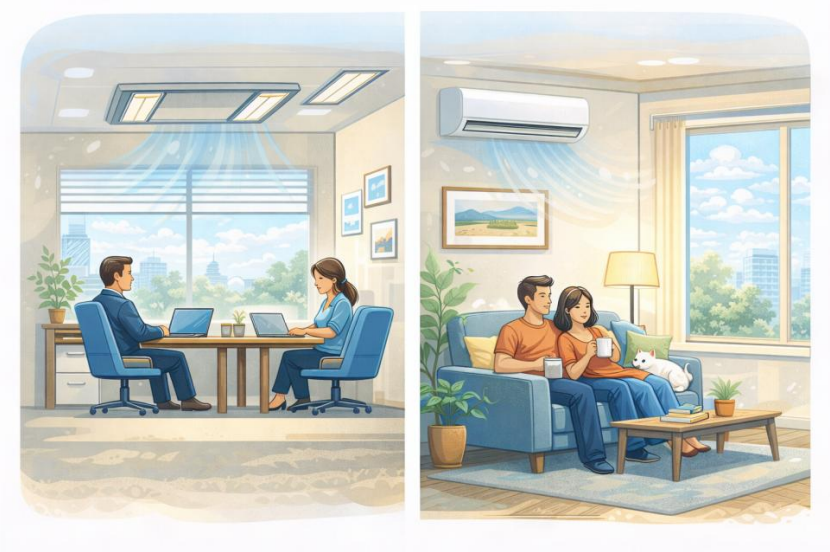
Building services play a very important role in making a building useful and comfortable. Their main uses are explained below in simple language:

• **Make buildings habitable:**

Building services provide basic facilities like water supply, electricity, sanitation, lighting, and ventilation, which are necessary for people to live, work, or study in a building.

• **Improve quality of life:**

Proper lighting, fresh air, comfortable temperature, and clean surroundings make living and working conditions pleasant and increase comfort and productivity of occupants.



• **Ensure safe living and working conditions:**
Fire protection systems, electrical safety measures, emergency alarms, and proper ventilation help in protecting life and property and reduce the risk of accidents.

• **Support special functions:**

Special buildings such as hospitals, industries, shopping malls, and educational institutions require specific services like medical gas systems, heavy power supply, air conditioning, and fire safety, which are provided by building services.

• **Increase building life and value:**

Well-planned and properly maintained building services reduce wear and tear, lower maintenance costs, and increase the overall life, efficiency, and value of the building.

5. Classification of Building Services

Building services are systems provided in buildings to ensure **comfort, safety, health, efficiency, and functionality** of occupants. As per **NBC 2016**, building services are mainly covered under **Part 4, Part 8, and Part 9**.

5.1 Mechanical Services

Mechanical services deal with **thermal comfort, vertical movement, and fire safety**.

5.1.1 HVAC (Heating, Ventilation and Air Conditioning)

HVAC systems are an essential part of **mechanical building services**, responsible for providing **thermal comfort, adequate ventilation, and acceptable indoor air quality (IAQ)** for occupants.

Definition and Purpose

- **Heating**: Maintains indoor temperature during cold conditions
- **Ventilation**: Supplies fresh outdoor air and removes stale air, odours, and pollutants
- **Air Conditioning**: Controls **temperature, humidity, air cleanliness, and air movement**
- **HVAC systems ensure:** Occupant comfort, Improved productivity, Health and well-being, Protection of equipment and materials

Importance of HVAC in Buildings

- Essential in:
    - ✓ Commercial buildings (offices, malls, hotels)
    - ✓ Institutional buildings (hospitals, educational buildings)
    - ✓ High-rise residential and mixed-use buildings
- Required where:
    - ✓ Natural ventilation is insufficient
    - ✓ Internal heat gains are high (computers, lighting, occupants)

- Critical for:
    - ✓ Hospitals (infection control)
    - ✓ Data centers (equipment protection)
    - ✓ Auditoriums and theatres (controlled environment)

NBC 2016 Provisions

NBC 2016, Part 8, Section 3 – Heating, Ventilation and Air Conditioning

- HVAC systems must be:
    - ✓ Energy-efficient
    - ✓ Properly designed and maintained
    - ✓ Integrated with fire safety systems
- Emphasis on:
    - ✓ Adequate fresh air supply
    - ✓ Thermal comfort
    - ✓ Noise control
    - ✓ Indoor air quality

Recommended Indoor Comfort Conditions

Parameter	Recommended Value
Summer temperature	**23–26°C**
Winter temperature	**21–23°C**
Relative humidity	**40–60%**
Air velocity	**0.15–0.25 m/s**

- These conditions are based on **human comfort studies** and **physiological requirements**.

Ventilation Requirements (NBC & IS)

Definition:

Ventilation is the process of **supplying fresh air** to and **removing stale air** from a building to maintain **healthy and comfortable indoor conditions**.

Types of Ventilation

- **Natural Ventilation**
    - ✓ Achieved through **windows, louvers, vents, and open spaces**.
    - ✓ Relies on **wind pressure and temperature differences**.
    - ✓ Advantages: Energy-efficient, low maintenance.
    - ✓ Limitations: Depends on weather, wind, and building orientation.
    - ✓ *Example:* Classrooms with large windows or cross-ventilation in homes.
- **Mechanical Ventilation**
    - ✓ Uses **fans, blowers, and Air Handling Units (AHUs)** to circulate air.
    - ✓ Can control **air quality, temperature, and humidity** precisely.
    - ✓ Suitable for **sealed buildings, hospitals, and high-rise offices**.
    - ✓ *Example:* Central AC systems in malls or ICUs in hospitals.
- **Mixed-Mode Ventilation**
    - ✓ Combination of **natural and mechanical ventilation**.
    - ✓ Optimizes energy use while ensuring indoor comfort.
    - ✓ *Example:* Offices using natural ventilation in mornings and mechanical AC in peak heat hours.

NBC (National Building Code) Recommendations

- **Maximize natural ventilation** wherever feasible.

- Provides guidelines for **minimum fresh air supply per person**:
    - Offices: 5–10 L/s per person
    - Classrooms: 3–6 L/s per student
- Ensures **adequate air changes per hour (ACH)** for different spaces:
    - Living spaces: 3–5 ACH
    - Kitchens, labs: 6–10 ACH
- Encourages **mechanical ventilation** for high-rise, sealed, or special-use buildings.

Examples for Classroom Understanding

Type	Example Building	Method
Natural	Residential homes, schools	Windows, vents, cross-ventilation
Mechanical	Hospitals, IT offices, malls	AHUs, fans, ducts, central HVAC
Mixed-mode	Modern offices, auditoriums	Daytime natural airflow + evening AC usage

Factors to be Considered in the Design of Ventilation

- ✓ **Occupancy of the Space**
    - Number of occupants and duration of stay affect fresh air requirement.
- ✓ **Purpose / Use of Building**
    - Ventilation needs vary for residences, offices, classrooms, hospitals, and industrial buildings.
- ✓ **Air Change Requirement**
    - Required air changes per hour (ACH) depend on room function and pollution level.
- ✓ **Size and Volume of Room**
    - Larger rooms require higher quantity of fresh air for effective ventilation.
- ✓ **Outdoor Climatic Conditions**
    - Temperature, humidity, wind speed, and direction influence ventilation design.

- ✓ **Indoor Air Quality Requirements**
  - Removal of CO_2, odors, fumes, dust, and contaminants.
- ✓ **Type of Ventilation System**
  - Natural ventilation, mechanical ventilation, or mixed-mode system.
- ✓ **Location and Size of Openings**
  - Proper placement of windows, ventilators, and exhaust outlets for effective air flow.
- ✓ **Orientation of Building**
  - Orientation with respect to prevailing wind improves natural ventilation.
- ✓ **Internal Layout of Rooms**
  - Furniture arrangement and partitions should not obstruct air movement.
- ✓ **Heat and Moisture Generation**
  - Kitchens, bathrooms, laboratories, and industries require higher ventilation rates.
- ✓ **Noise Control**
  - Ventilation system should not cause discomfort due to excessive noise.
- ✓ **Energy Efficiency**
  - System should minimize energy consumption while ensuring comfort.
- ✓ **Safety and Health Requirements**
  - Proper ventilation to prevent buildup of harmful gases and ensure occupant safety.

Types of HVAC Systems

Definition:

HVAC systems are classified based on **the method of air distribution, heating, and cooling**, and their application in buildings.

1. All-Air Systems

Conditioning is done entirely using air supplied through ducts from a central unit. **Example:** Central air conditioning in shopping malls and large office buildings.

2. All-Water Systems

Heating or cooling is achieved by circulating chilled or hot water to fan coil units or radiators. **Example:** Chilled water systems used in hotels and hospitals.

3. Air-Water (Combined) Systems

Uses both conditioned air and chilled/hot water to control temperature and humidity efficiently. **Example:** HVAC systems in modern high-rise office buildings and hospitals.

4. Packaged Systems

Factory-assembled air-conditioning units installed outdoors or on rooftops and connected by ducts. **Example:** Small offices, schools, and retail stores.

5. Split Systems

Consists of separate indoor and outdoor units connected by refrigerant piping. **Example:** Residential air conditioners (1–2 TR) and small offices.

6. VRF / VRV Systems

Supplies variable refrigerant flow to multiple indoor units, allowing precise zone control. **Example:** Hotels, shopping complexes, and high-rise commercial buildings.

7. Rooftop Units (RTU)

Self-contained HVAC units installed on rooftops for conditioning large single spaces. **Example:** Auditoriums and large single-floor retail outlets.

NATURAL LIGHTING (DAYLIGHTING)

Definition

Natural lighting is the use of **sunlight and skylight** to illuminate building interiors during daytime.

Principles

- Make maximum use of available daylight.
- Ensure **uniform distribution** of light inside rooms.
- Avoid **glare and sharp shadows**.
- Reduce **heat gain** while allowing sufficient light.
- Improve **visual comfort** and reduce energy consumption.

Factors Affecting Natural Lighting

1. **Orientation of Building** – North-facing openings give uniform light; east/west cause glare.
2. **Size of Openings** – Larger windows admit more light.
3. **Position of Openings** – Higher windows distribute light deeper into rooms.
4. **Room Depth** – Daylight penetration reduces with increased room depth.
5. **External Obstructions** – Adjacent buildings, trees, chajjas reduce light.
6. **Surface Reflectance** – Light-colored walls and ceilings reflect more light.
7. **Type of Glass** – Clear glass gives more light than tinted glass.

Advantages

- Saves electrical energy, Improves health and comfort, Environment friendly

Applications

- Residential buildings, Classrooms, Offices, Hospitals

ARTIFICIAL LIGHTING

Definition

Artificial lighting is illumination provided using **electrical light sources** such as lamps and luminaires.

Principles

- Provide **adequate illumination** for the intended task.
- Ensure **uniform lighting** in the space.
- Control **glare** and excessive brightness.
- Use **energy-efficient lighting systems**.

- Create suitable **ambience** as per room use.

Factors Affecting Artificial Lighting

1. **Illumination Level (Lux)** – Depends on type of activity.
2. **Type of Lamp** – LED, fluorescent, etc.
3. **Mounting Height** – Affects light spread and intensity.
4. **Spacing of Lights** – Proper spacing ensures uniform lighting.
5. **Color Temperature** – Warm light for homes, cool light for offices.
6. **Glare Control** – Use diffusers, shades, correct fixture design.
7. **Maintenance Factor** – Dust and aging reduce light output.

Advantages

- Can be used anytime (day or night), Easy control of light intensity, Uniform and reliable lighting

Applications

- Night lighting in buildings, Laboratories, Auditoriums, Factories, Street lighting

UNIT II – ELECTRICAL SERVICES IN BUILDINGS

1. Introduction to Electrical Services in Buildings

Electrical services are an essential part of any building, ensuring **safe, reliable, and efficient supply of electrical power** for lighting, appliances, HVAC systems, lifts, fire protection, and other utilities.

Objectives of Electrical Services

- ✓ **To provide adequate and continuous power supply:** Electrical services are designed so that sufficient electricity is available at all times for lighting, fans, appliances, lifts, and machines without frequent power interruptions.

- ✓ **To ensure safety of occupants :** Proper electrical planning prevents electric shock, short circuits, and fire hazards, thereby protecting people living or working in the building.

- ✓ **To reduce energy losses :** Good quality wiring, proper conductor size, and correct electrical layout help in minimizing loss of electrical energy during transmission and use.

- ✓ **To allow easy maintenance and future expansion :** Well-planned electrical systems make inspection, repair, and addition of new electrical points simple without disturbing the existing system.

- ✓ **To comply with IS codes and National Building Code (NBC) :** Electrical installations are carried out as per IS standards and NBC guidelines to ensure safety, reliability, and legal approval of the building.

2. Electrical Services Layout in Different Types of Buildings

2.1 Residential Buildings

- ✓ **Lighting Circuits:** Lighting circuits are provided to supply electricity to lights such as bulbs, tube lights, and LED fixtures, and they are designed to carry low power load safely.
  (LED Bulb: **9–12 W,** LED Tube Light (4 ft): **18–20 W,** CFL (older type): **15–23 W)**

- ✓ **Fan and Socket Outlets:** Fan points and socket outlets are used to operate ceiling fans and to connect small electrical appliances like chargers, television, and mixer.
  (Conventional fan: **70–90 W,** Energy-efficient (BLDC) fan: **25–35 W,** Mobile charger: **5–10 W,** Television (LED): **80–150 W,** Mixer grinder: **500–750 W,** Laptop: **60–90 W)**

- ✓ **Power Points for Appliances (AC, Geyser, and Refrigerator):** Separate power points are provided for heavy appliances like air conditioners, geysers, and refrigerators because they require higher current and safe operation.
  (Air Conditioner (1–1.5 Ton): **1200–2000 W,** Geyser (Water Heater): **1500–3000 W,** Refrigerator: **150–300 W,** Washing Machine: **500–800 W,** Microwave Oven: **1000–1500 W)**

- ✓ **Distribution Board (DB) for Each Floor/Flat:** A distribution board is installed on each floor or flat to distribute electrical power to different circuits and to provide protection using MCBs.

(Typical connected load per flat (1–2 BHK): **3–6 Kw,** Typical connected load per flat (3 BHK): **5–8 kW)**

Relationship between Watt, Ampere, and Volt

P = V x I

P = Power in **Watts (W)** [Single Phase : 2000 W, Three Phase :10000 W]

V = Voltage in **Volts (V)** [Single Phase :**230 V**, Three Phase :415]

I = Current in **Amperes (A)**

- ✓ **For AC Circuits (Single Phase)**

  P = V x I x cos Ø

  Where: cos Ø = **Power factor** (0.8–1.0 for residential loads)

- ✓ **For AC Circuits (Three Phase)**

  P = √3 x V x I x cos Ø

Appliance	**Suggested Socket**	**Capacity**
Ceiling Fan (70–90 W)	6A	Adequate
BLDC Fan (25–35 W)	6A	Adequate
Mobile Charger (5–10 W)	6A	Adequate
Laptop (60–90 W)	6A	Adequate
LED TV (80–150 W)	6A	Adequate
Mixer Grinder (500–750 W)	6A (dedicated)	Adequate

2.2 Commercial Buildings

- ✓ **High illumination requirements:** Commercial buildings require higher illumination levels to ensure visual comfort, productivity, and safety.

- ✓ **Separate power circuits for office equipment:** Dedicated power circuits are provided to handle heavy loads and protect sensitive office equipment.

- ✓ **Emergency lighting:** Emergency lighting ensures safe evacuation and visibility during power failures or emergencies.

- ✓ **Earthing and lightning protection:** Proper earthing and lightning protection safeguard occupants and equipment from electrical faults and lightning strikes.

2.3 Industrial Buildings

- ✓ **Heavy power installations:** Industrial buildings require heavy power installations to support high-load machinery and equipment.

- ✓ **Three-phase supply:** A three-phase power supply is used to efficiently meet large and continuous power demands.

- ✓ **Motors and control panels:** Motors with control panels are installed for safe, efficient operation and control of industrial processes.

- ✓ **Proper grounding and protection devices:** Effective grounding and protection devices prevent electrical hazards and equipment damage.

2.4 Public Buildings

- ✓ **Fire-resistant wiring:** Fire-resistant wiring is used to maintain circuit integrity and reduce risk during fire conditions.

- ✓ **Emergency power supply:** An emergency power supply ensures continuous operation of essential services during power failures.

- ✓ **Exit and emergency lighting:** Exit and emergency lighting provide clear guidance for safe evacuation in emergency situations.

- ✓ **Energy-efficient systems:** Energy-efficient systems reduce power consumption while maintaining required performance levels.

3. Technical Terms Used in Electrical Installations

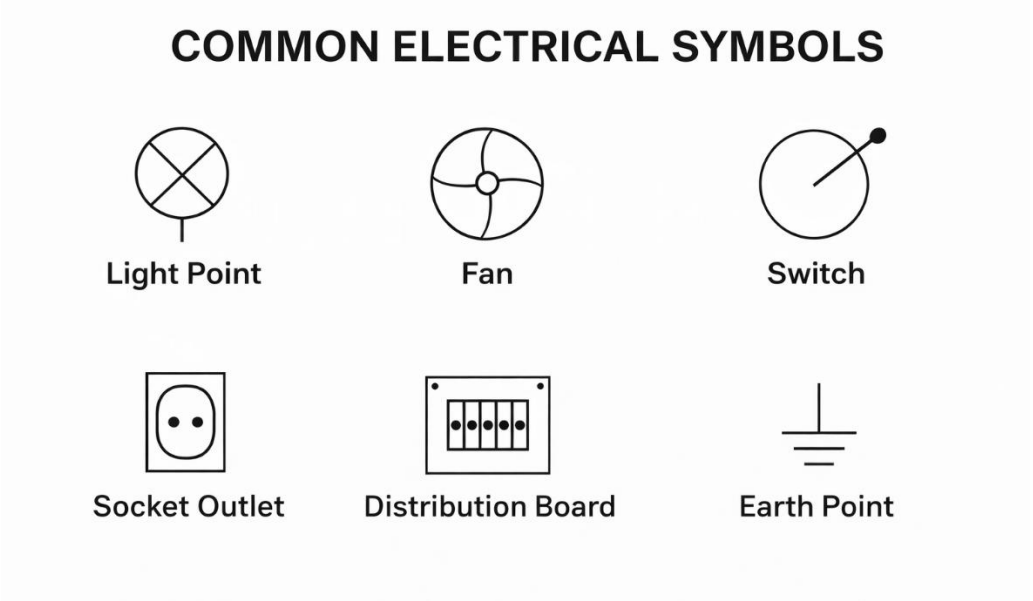
Term	Description
Voltage (V)	Electrical potential difference
Current (A)	Flow of electric charge
Watt (W)	Unit of electrical power
kWh	Unit of electrical energy
Fuse	Protective device that melts under excess current
MCB	Automatically trips during overload
Earthing	Safe discharge of fault current to ground

4. Electrical Symbols

Standard symbols are used in electrical drawings as per **IS 2032**.

Common Symbols

- ✓ Light point
- ✓ Fan
- ✓ Switch
- ✓ Socket outlet
- ✓ Distribution board
- ✓ Earth point



5. Types of Electrical Wiring

5.1 Cleat Wiring

Cleat wiring uses insulated wires supported on porcelain cleats. It is low cost and suitable only for temporary use.

Application Areas:

- ✓ Temporary installations , Construction sites, Exhibitions and fairs, Testing purposes in laboratories

5.2 Batten Wiring

In batten wiring, PVC insulated wires are fixed on a wooden batten with clips. It is simple and economical.

Application Areas:

- ✓ Low-cost houses, Small residential buildings, Shops and small offices, Rural installations

5.3 Casing and Capping Wiring

Wires are enclosed inside wooden or PVC casing and covered with a cap. It offers moderate protection and neat appearance.

Application Areas:

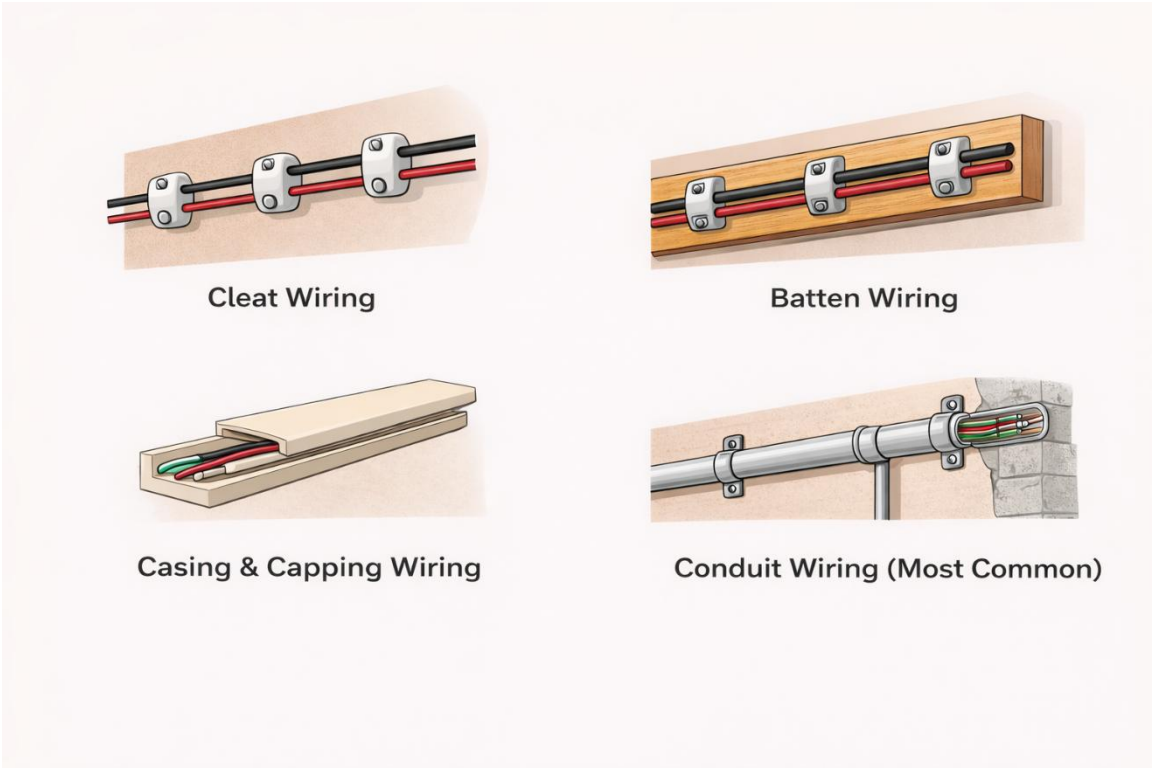
- ✓ Residential buildings (old construction), Small commercial establishments, Light-load domestic installations

5.4 Conduit Wiring (Most Common)

Wires are run through PVC or metal conduits. It can be surface or concealed type. It provides maximum safety and durability.

Application Areas:

- ✓ Modern residential buildings, Commercial complexes, Hospitals and educational institutions, Industrial buildings, High-rise apartments



6. Types of Insulation

Insulation is the material used to cover electrical conductors to prevent **leakage current, short circuits, and electric shock**. It protects users from accidental contact and improves the safety and durability of wiring systems.

Functions of Insulation

- ✓ Prevents leakage of current
- ✓ Protects against electric shock
- ✓ Avoids short circuits between conductors
- ✓ Protects wires from moisture, heat, and mechanical damage
- ✓ Increases life of electrical installations

Common Insulating Materials

1. PVC (Polyvinyl Chloride)

PVC is the most widely used insulating material in electrical wiring.

Properties: Good insulation resistance , Moisture resistant, Chemical resistant, Flexible and lightweight, Low cost

Advantages: Durable and long-lasting, Fire-resistant (flame retardant type available), Easy to install

Applications: Domestic wiring, Industrial cables, Flexible cords, Conduit wiring systems

2. Rubber Insulation

Natural or synthetic rubber is used for insulation in flexible cables.

Properties: High elasticity, Good insulation strength, Good flexibility

Advantages: Suitable for flexible wires, Good resistance to wear

Disadvantages: Affected by heat and sunlight, Shorter life compared to PVC

Applications: Portable appliances, Temporary wiring, Flexible cables

3. Varnished Cambric

Cambric is a cotton fabric coated with insulating varnish.

Properties: Good dielectric strength, Flexible, Heat resistant

Advantages: Better heat resistance than rubber, Good mechanical strength

Disadvantages: Costlier, Mostly replaced by modern insulation materials

Applications: Transformer windings, Motor windings, Older cable systems

4. XLPE (Cross-linked Polyethylene)

XLPE is an advanced insulating material formed by cross-linking polyethylene.

Properties: High temperature resistance, Excellent dielectric strength, High mechanical strength, Moisture resistant

Advantages: Suitable for high voltage, Long service life, Low dielectric losses

Applications: Underground cables, High-voltage power transmission, Industrial power distribution

Insulation	Strengths	Weaknesses	Best For
PVC (Polyvinyl Chloride)	Moisture and chemical resistant, flexible, low cost, durable	Limited heat resistance (up to ~70°C), not ideal for high voltage	Domestic wiring, general-purpose cables, conduit wiring
Rubber	High flexibility, good wear resistance	Degrades with heat, sunlight, and over time	Flexible cords, portable appliances, temporary wiring
Varnished Cambric	Good heat resistance, mechanical strength	Expensive, outdated, mostly replaced	Transformer/motor windings, legacy cables
XLPE (Cross-linked Polyethylene)	Excellent heat and dielectric strength, moisture-resistant, durable, low losses	Slightly higher cost, less flexible than PVC	High-voltage cables, underground cables, industrial power distribution

7. Single Phase and Three Phase AC System

7.1 Single Phase System

- Used in residential buildings , Voltage: **230 V,** Suitable for low power loads

7.2 Three Phase System

- Used in commercial and industrial buildings, Voltage: **415 V,** More efficient, Used for motors and heavy machinery

Difference Between Single Phase & Three Phase

Aspect	Single Phase	Three Phase
Voltage	230 V	415 V
Power	Low	High
Usage	Homes	Industries
Efficiency	Low	High

8. Miniature Circuit Breaker (MCB)

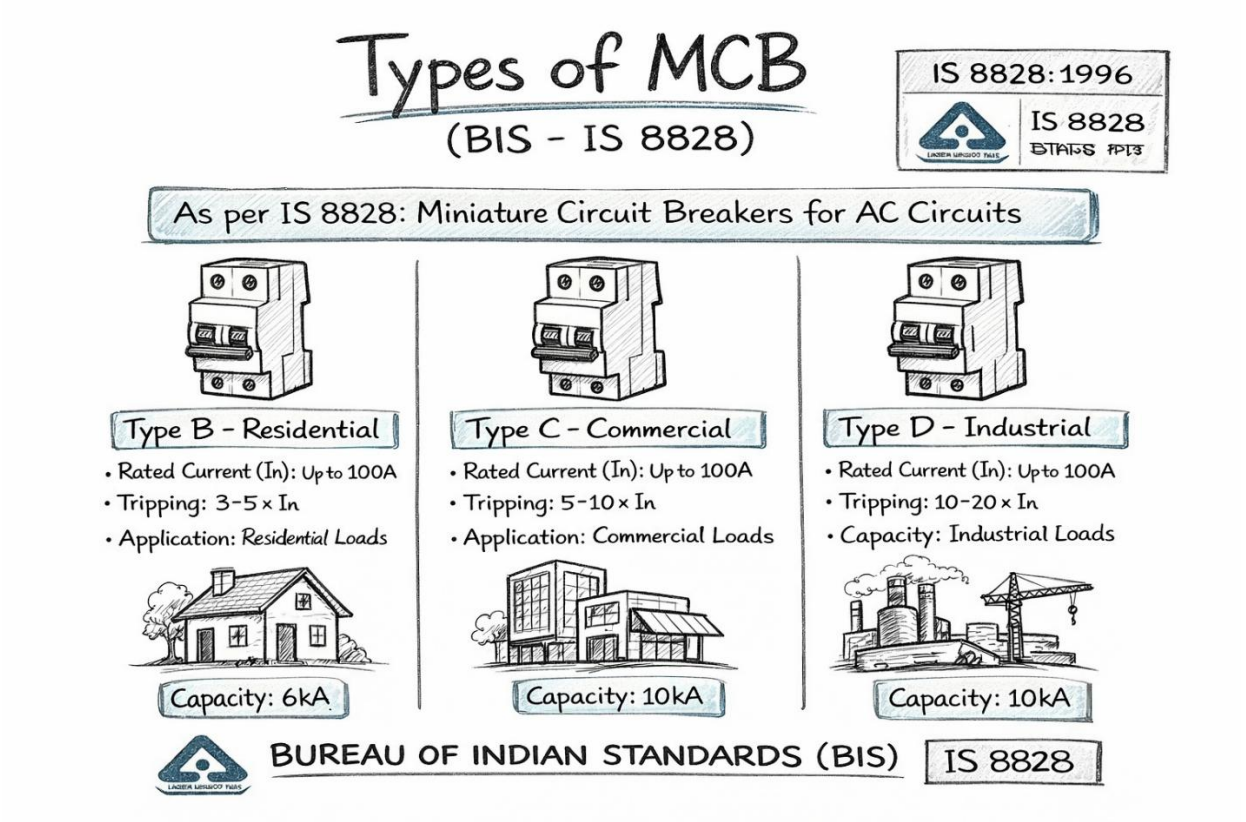
Definition

MCB is an **automatic protective device** that trips during overload or short circuit.

Advantages: Quick response, Resettable, Compact size, Safer than fuse

Types of MCB

Type	Tripping Characteristic	Typical Application	Capacity / Rating
Type B	Trips at 3–5 × rated current	Residential Loads	Up to 100 A, 6 kA
Type C	Trips at 5–10 × rated current	Commercial Loads	Up to 100 A, 10 kA
Type D	Trips at 10–20 × rated current	Industrial Loads (motors, heavy machinery)	Up to 100 A, 10 kA



9. Earthing / Grounding

Definition

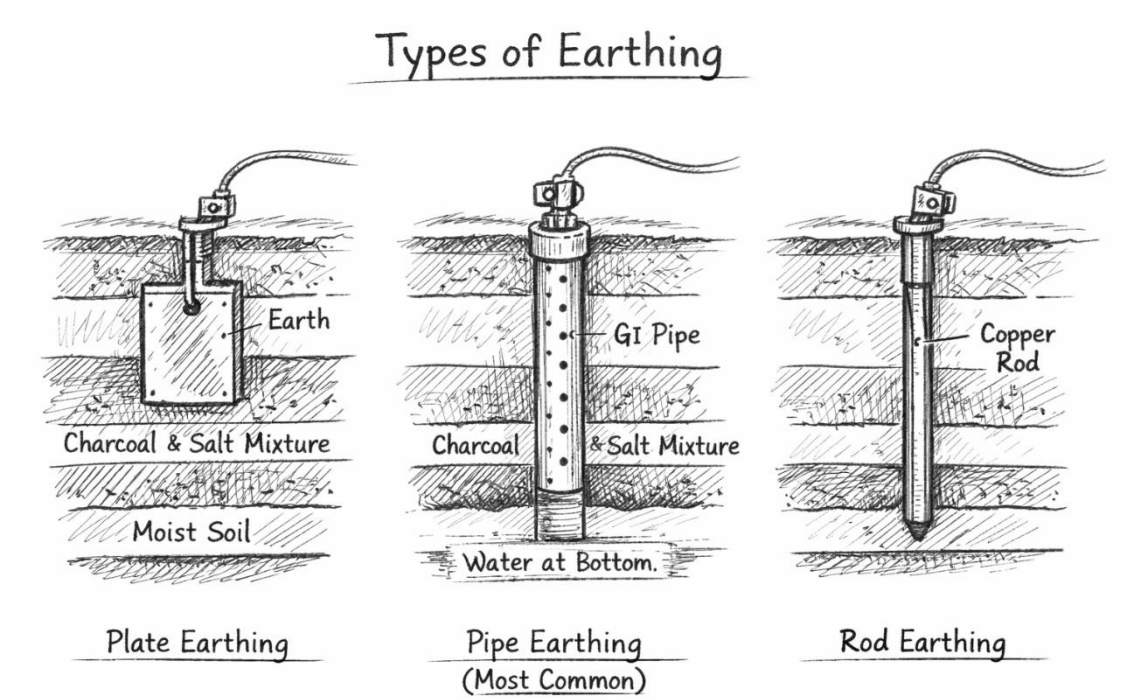
Earthing is the process of connecting **non-current carrying parts** of electrical equipment to earth.

Purpose of Earthing

- Prevent electric shock, Protect equipment, Stabilize voltage, Dissipate fault current

Types of Earthing

- Plate earthing
- Pipe earthing (most common)
- Rod earthing



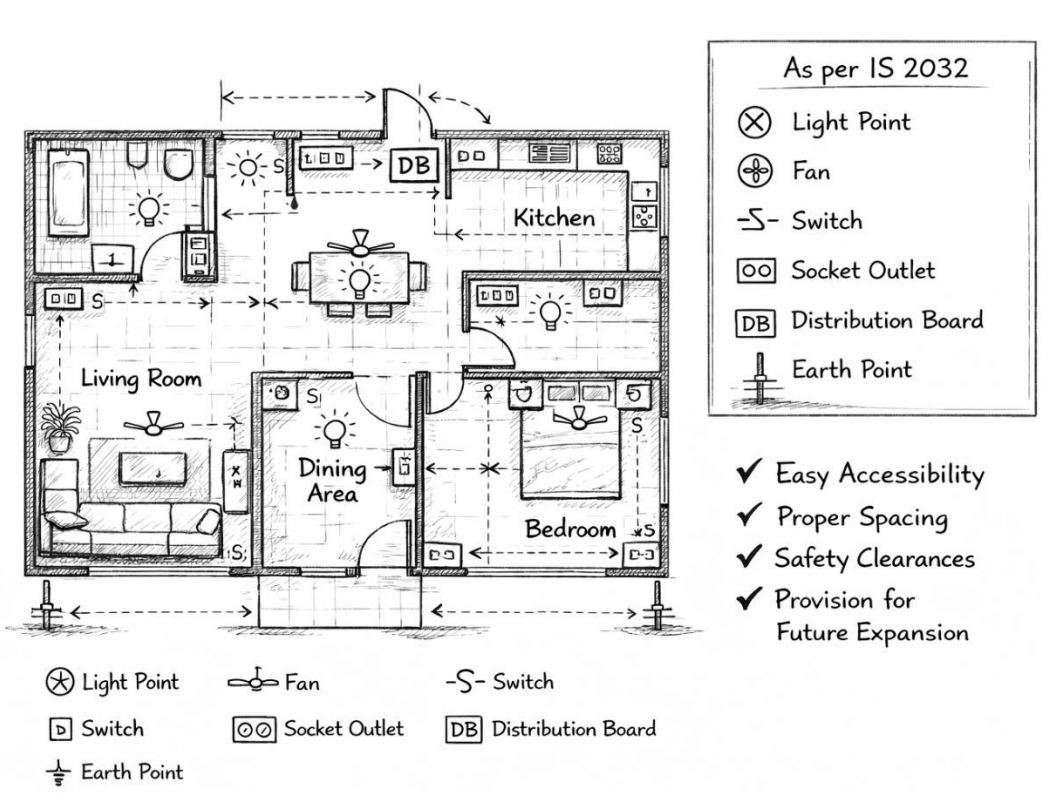
ISI Specifications

- As per **IS 3043**
- Earth resistance should be low
- Use of copper/GI electrodes

10. Electrical Plan for Buildings

Components : Light points , Switch boards, Plug points, DB location, Earthing points

Guidelines: Easy accessibility, Proper spacing, Safety clearances, Provision for future expansion



11. Solar Power System

Definition

Solar power uses **photovoltaic cells** to convert sunlight into electricity.

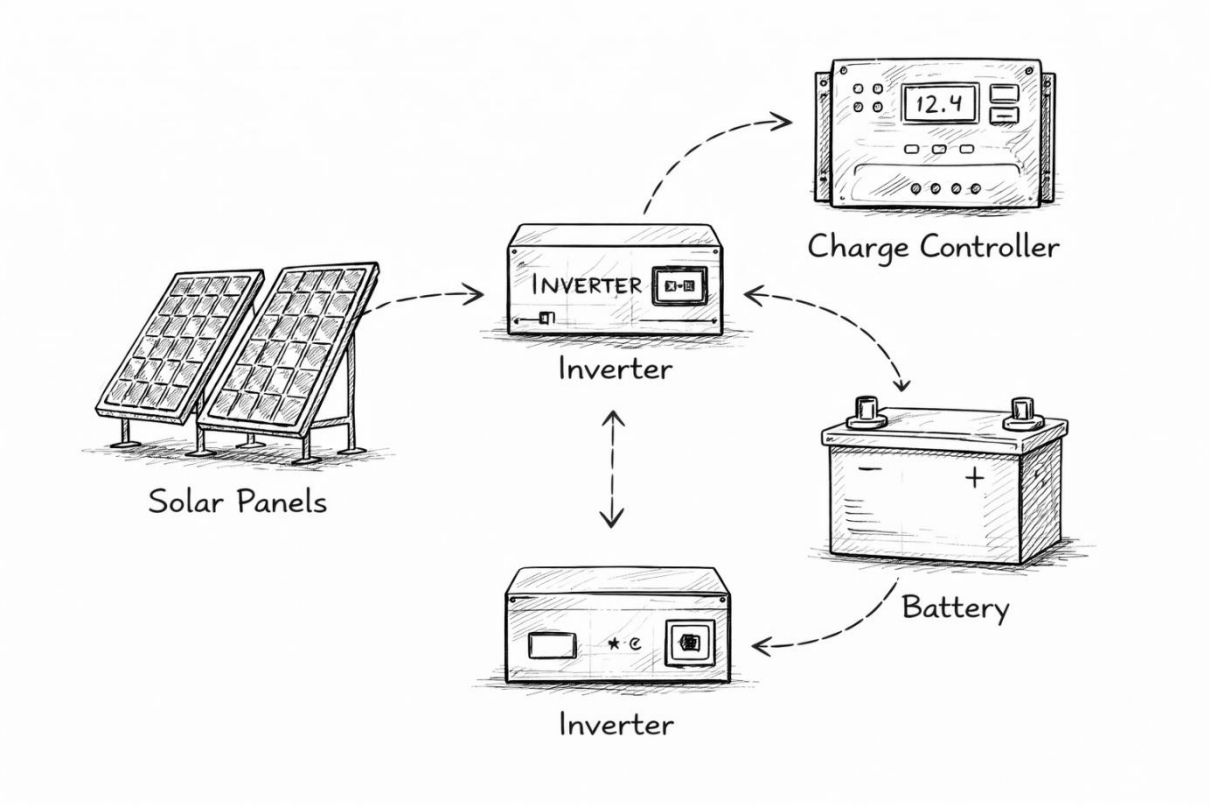
Components

- Solar panels

- Inverter
- Battery
- Charge controller

Advantages

- Renewable energy
- Reduces electricity bills
- Environment friendly
- Low maintenance



Generation

Solar System Size	Daily Generation	Monthly Generation	Yearly Generation
1 kW	4–5 units	120–150 units	1400–1800 units
3 kW	12–15 units	360–450 units	4200–5400 units
5 kW	20–25 units	600–750 units	7000–9000 units